p. 60.
A Bud failure disorder in Almond
Tyler
By E. E. Wilson & G. L. Stout

VOLUME XXXIII NUMBER 1

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DEPARTMENT OF AGRICULTURE

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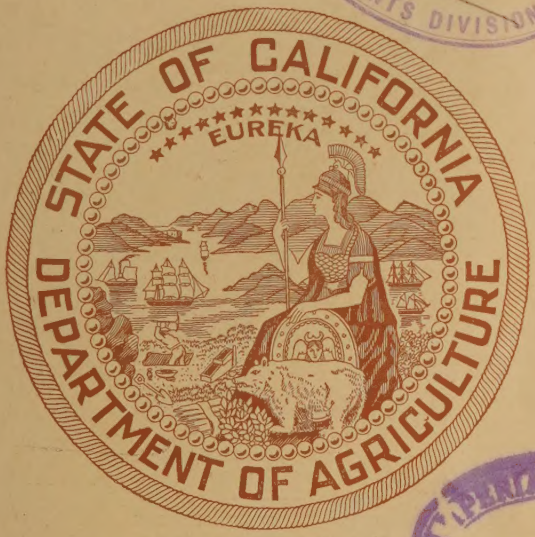

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JANUARY FEBRUARY MARCH 1944

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THE BULLETIN

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WILLIAM J. CECIL.....Director

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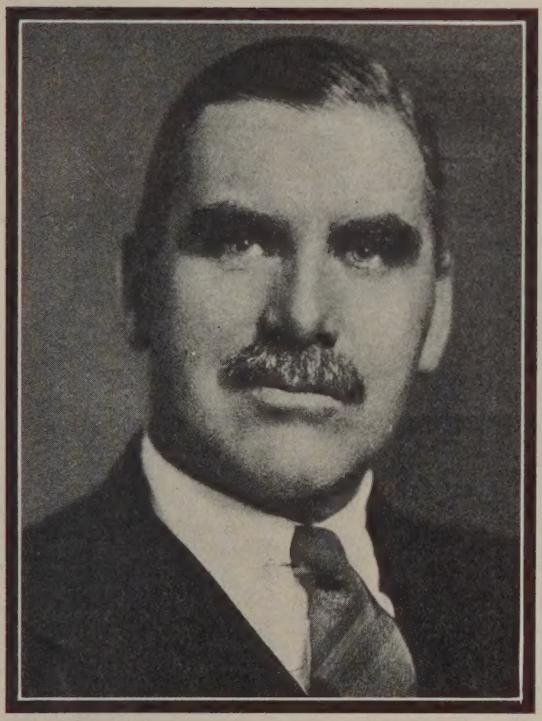
DR. LEONARD S. McLAINE



Dr. Leonard S. McLaine

It is with profound sorrow that we received notice of the untimely passing of a distinguished friend and co-worker, Dr. Leonard S. McLaine, Dominion Entomologist, in his summer home at Lake Bernard, Quebec. His death is a distinct loss to the entomological profession, as well as to his government.

Dr. McLaine's scientific ability and administrative capacity were of a high order and were early recognized. In 1913 he joined the Entomological Staff of the Canadian Government and in 1917 was transferred to Ottawa as Chief of the newly organized Division of Foreign Pest Suppression. In 1933 he reorganized the plant inspection system of Canada; in 1938 he was appointed Chief of the Plant Protection Division of the Dominion Department of Agriculture and in 1941 he became Dominion Entomologist.

California and the Western States Agricultural Officials became acquainted with Dr. McLaine in 1922 when he attended the fourth meeting of the Western Plant Board in Sacramento. He was intensely interested in the activities and problems of the Regional Plant Boards and attended their meetings whenever opportunity afforded. His advice was eagerly sought and he made many friends.

For distinguished service in his chosen field the Degree of Doctor of Science was conferred on Dr. McLaine by his Alma Mater, Massachussetts Agricultural College.

D. B. Mackie, Chief
Bureau of Entomology and Plant Quarantine

ONE YEAR WITH THE ORIENTAL FRUIT MOTH

D. B. MACKIE, Chief, Bureau of Entomology and Plant Quarantine

In the course of a routine inspection of lemon trees which were interplanted with 129 peach trees on the Hughes Estate in the Yorba Linda District, G. V. House, an inspector on the staff of the Agricultural Commissioner of Orange County, on September 30, 1942, collected a pinkish larvae from a peach twig. The specimen went through the regular channels of the commissioner's office and on October 5th was received at the office of the California Department of Agriculture where it was tentatively identified as the Oriental fruit moth. This identification was later confirmed.

The situation created by finding the Oriental fruit moth established in the State, undoubtedly presented the most difficult entomological problem with which California's agricultural officials and entomologists have had to deal.

In support of this conclusion the following data are presented:

1. The host index of the moth includes a large proportion of the species which make up the State's great deciduous fruit industry.

2. According to the Office of Crop Statistics of the United States Department of Agriculture, the value of the crops in this host group in 1942 was $115,899,000.

3. The moth attacks both twig and fruit. Its habit of casting aside the first mouthfuls and not feeding until it is well within the fruit renders it largely immune to the ordinary methods of control employed against chewing insects.

4. Its vagrant habits lead it to hibernate in any convenient location such as in the ground, in rolled-up leaves, fruit, mummified fruit, fence posts, etc., and makes success in any program of eradication exceedingly remote.

5. In its new home a whole new complex of native and ornamental species contributes to its potential host index and gives promise of adding more.

As might be expected, the impact resulting from the discovery of this insect pest has had far-reaching effects, and is reflected in the amount of money asked of the Legislature to deal with it. The sum exceeds by a considerable figure the total amount appropriated for the activities of the Entomological Service, exclusive of special appropriations to deal with citrus white fly and date palm scale eradication, for the past 20 years.

At this writing slightly over a year has passed since the first specimen was received and during this period entomologists and agricultural officials have had considerable opportunity to study the moth, its development and its distribution in California, and the problem of dealing with it.

The following is a resume of what happened during this preliminary period when a program to deal with the moth was in the process

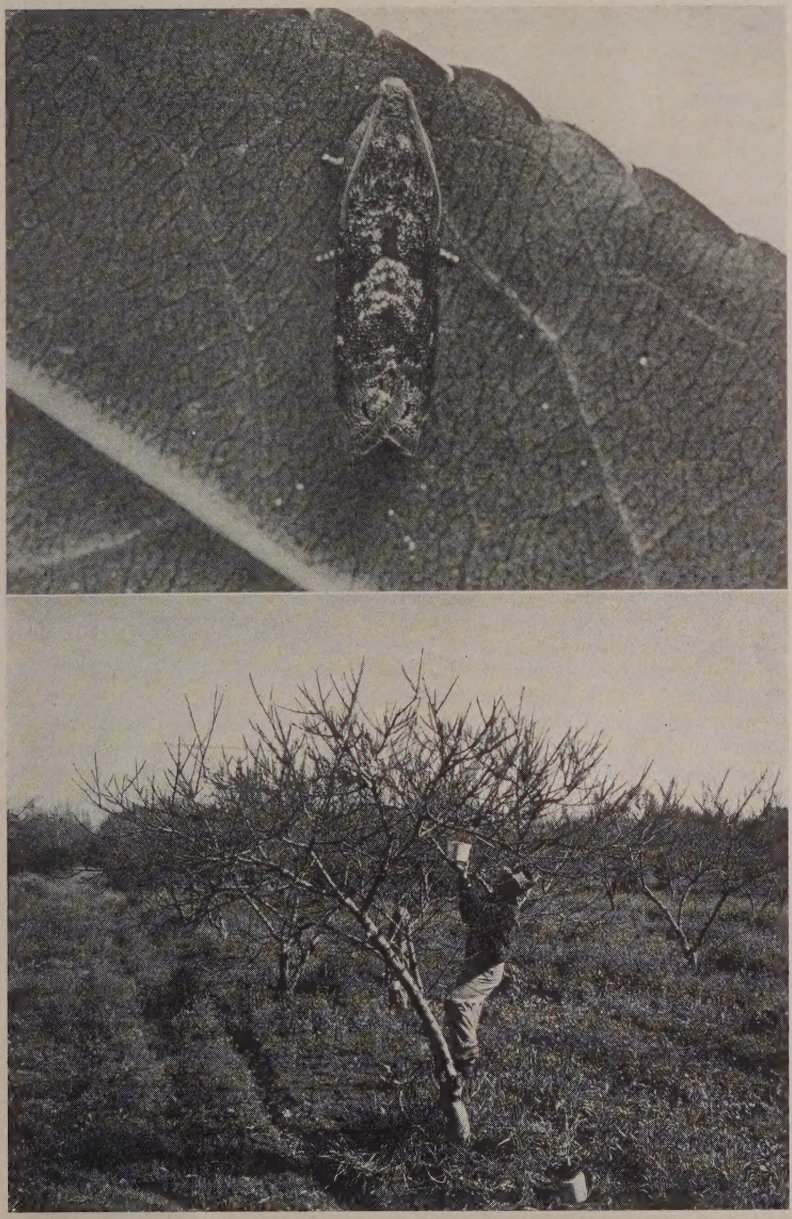


FIG. 1. Top. Oriental Fruit Moth Adult on Leaf of Peach. (x5)
Bottom. Installing a Bait Trap in a Peach Tree.

of formulation. All were agreed that the financial investment in host crops and processing equipment was of a sufficient value to justify exploration of every approach looking to eradication.

There was considerable diversity of opinion, even among entomologists, on the question of whether or not eradication could be accomplished. Of the various shades of opinion expressed in preliminary hearings to consider a program of dealing with the moth, the following represent the two extremes: (1) That an all-out eradication program should be started immediately and persisted in, involving removal and destruction of all known hosts in the belief that the moth would thereby be eradicated by starvation; (2) the other group opposed an all-out eradication program on the grounds that there existed reasonable probability that the moth was distributed over a much wider territory than it was then known to infest and that under California conditions new hosts would be found, a list of which would include economic, ornamental and native species. It was also argued that in considering eradication no single program could be laid down that, even if persistently adhered to, would yield cumulative results. Furthermore, the consequences of failure would have far-reaching repercussions and might reasonably be expected to interfere with future handling of the problem, to say nothing of the destruction of valuable fruit holdings.

Preliminary Organization

The department's Oriental fruit moth activities immediately were made an emergency project. To expedite the development of information on distributional status in California, the Director of Agriculture made immediately available $100,000 from current savings within the department. This fund enabled organization of surveys and establishment of inspection stations to prevent the distribution of agricultural commodities that might act as carriers. These latter were in the nature of sampling stations to study the amount of host material being transported and for distribution of literature informing people of the danger of disseminating pests through host fruits, second-hand boxes and other vectors.

Surveys

Surveys started by State and county crews in Orange County in October, 1942, revealed that practically all of Orange County was infested, though the infestation was somewhat scattered and spotted. While no moths were found beyond the borders of that county, it was recognized that expectancy of finding infestation at that time was at a seasonal low, the larvae being in winter hibernation. Work in this connection was greatly facilitated by the action of Agricultural Commissioner Tubbs of Orange County, who made available to the department the buildings of the county insectary at Anaheim which became project headquarters.

Trapping. Trapping started in March. Originally it had been intended that spring and summer surveys would be confined to examination of the twigs. The belief that higher efficiency would be obtained by trapping caused this change in the State's program. Trap lines were placed in various counties adjacent to the original infestation.

Moths were taken in San Bernardino, Riverside and Los Angeles counties in the order reported. In addition, further finds were made in Orange County. By late June it was recognized that the moth was generally established in these four counties and also existed in considerable numbers in the vicinity of the Wholesale Terminal Market in the City of Los Angeles, from which large shipments of host material moved to other states.

The first moths taken north of the Tehachapi Mountains were taken by C. S. Morley in the eastern part of Bakersfield on May 31st. Another specimen was collected in the western part of Bakersfield on June 16th. It was found in a residential property in the town of Wasco on June 14th and in large commercial peach plantings in the same locality on July 27th. On July 23d the moth was taken at Denair, in Stanislaus County, 200 miles to the north. On August 10th it was taken in the vicinity of Visalia, in Tulare County, and on September 28th at Rio Oso, in Sutter County. The survey was discontinued on October 15th due to seasonal considerations.

Some idea of the extent of the Oriental fruit moth project may be had from an examination of the following items:

The survey was carried on in 7,200 properties, located in 36 counties. Six tons of liquid diamalt syrup and four of dry diamalt, and approximately one ton of lignin pitch were used in the manufacture of baits. From this material there were prepared 114,780 gallons of bait which serviced approximately 18,587 traps. At the peak of travel loads 109 State and county inspectors were employed. Survey crews averaged 17,000 miles per week. Insofar as they are available, records indicate that approximately 364,000 miles were traveled in making surveys, not including mileage traveled by county inspectors, which was taken care of by the counties.

Identification of Collections. The department is fortunate in having on its staff one of the ranking authorities on the classification of microlepidoptera who recognized the potentialities in the original larval specimen received at the department on October 5, 1942.

Though the full implications of the original collection will probably never be realized by those whose interests are affected, there can be little doubt any delay in recognizing presence of Oriental fruit moth in the State would have contributed greatly to the complexity of the problem.

Two systematic entomologists and four laboratory assistants were necessary to handle incoming collections and to keep the records.

During the year from approximately 600,000 specimens examined, 60,367 determinations were made and indexed, and collectors were notified. The State average of this survey was one specimen of Oriental fruit moth per 10,000 moths examined. Between 50 and 60 species, representing 12 families of microlepidoptera were collected in which were represented 13 species of the family Olethreutidae to which the Oriental fruit moth and codling moth belong. Six of these species belong in the subfamily Laspeyresiinae and seven in the family Eucosminae. Some of these related species may be of interest as possible alternate hosts and furnish parasites which attack the Oriental fruit moth. A check list has been prepared giving the identity, feeding habits, numbers and range of all species taken and is available for distribution to interested parties.

Tree Banding. In areas of the San Joaquin, Sacramento and Santa Clara valleys some 38,611 peach trees were banded in autumn as a supplement to trapping. Particular attention was given to areas in the vicinity of locations where moths had been trapped, also areas adjacent to canneries, dry yards, etc. Removal of bands is now under way, though identification of the catch has not yet been made.

Legislation

One result of differences of opinion as to the merits of various programs is reflected in the approach to the legislative aspects of the problem. Special legislation to deal with the moth was carefully prepared to take care of any contingency and was presented in two bills, each dealing with separate aspects of the problem.

The first bill set up a program to provide for survey and quarantine stations to prevent distribution of the moth and to provide funds for research involving both its biological and chemical control and eradication other than tree removal. Under this bill the sum of $431,984 was requested.

The second bill provided $432,720 to be used for defraying the costs of removal of host plants and set aside $275,000 to reimburse growers for the loss of their trees.

Both Bills received the approval of the Legislature, were signed by the Governor, and became Chapters 613 and 614, Statutes of 1943.

Legislation approved by the 55th Legislature dealing with eradication of the Oriental fruit moth contains one chapter which is a radical departure in dealing with insect pests in that it provides for destruction of host trees and indemnification of owners for losses amounting to two-thirds of the appraised value of the trees condemned and destroyed under the Statutes. It provides for setting up a table of normal values to be used as a basis for payment for any trees removed in the eradication program, and provides for boards of appeal. Investigations in this field have been made a project of the University of California under R. L. Adams, Professor of Farm Management, who has submitted the results of his investigations and proposals to the Director of Agriculture.

At this writing no opportunity has been provided to observe the effects of enforcing the provisions dealing with host removal and indemnification. Considerable speculation has resulted in the minds of both agricultural officials and growers as to their enforceability.

Oriental Fruit Moth Advisory Committee

In March, 1943, the Director of Agriculture appointed an Advisory Committee composed of entomologists, agricultural officials, representatives of farmer organizations, the canning industry, fruit growers and shippers. The function of this committee was to enable the department to keep various agricultural industries and interested parties informed on developments in the Oriental fruit moth situation and to make recommendations to the director on broad matters of policy.

The committee has held seven meetings in different parts of the State where it received the reports of investigators and discussed aspects of the problem.

On July 22d the committee recommended that the counties of southern California south of the First Standard Parallel Line North (S.B.B.L.) be declared infested territory because scattered infestations were found over large areas in the counties of Orange, Riverside, San Bernardino and Los Angeles, and recommended that the quarantine be changed accordingly.

At a meeting on October 7th, as a result of finding the moth in Kern, Tulare, Stanislaus and Sutter counties, the committee unanimously recommended to the director that eradication by removal of hosts be abandoned due to the large number of properties involved, and further recommended that steps be taken to have the appropriations which had been set up for eradication and indemnification of growers reappropriated under the broader provisions of its companion bill, with greater funds made available for research.

Quarantines

To prevent the distribution of known hosts of the moth, both intrastate and interstate quarantines were promulgated in October, 1942. Road inspection stations which were more in the nature of traffic sampling stations and for purposes of education were established on the highways bordering Orange County. Inspection stations for intercepting contraband were out of the question under the conditions of traffic on the four-lane highways where cars averaged 75 per minute.

In addition to the foregoing, through its Nursery Service the State placed a "hold order" on all host plants which occurred in the known infested territory.

With the advent of spring and elaboration of the surveys it became necessary to increase road inspection. Findings of the moth at various points in Riverside, San Bernardino and Los Angeles counties made it impossible to draw up any adequate and workable plan to prevent dissemination. Though the staff had been expanded, the problem reached the point where it became no longer possible to set up free areas or to patrol the highways in a manner that would prevent distribution through human agency. The insidious nature of the moth, its minute size, and low population density were further contributing factors.

Some idea of the difficulties of obtaining representative samples of moth population for purposes of quarantine may be obtained from the fact that in a single peach orchard in San Bernardino County, suspected of being infested, it took two men operating 532 traps 27 days to secure one moth.

Trapping large orchards presents special problems. For example, a single orchard in Tulare County which has more peach trees than are planted in all of southern California required over 1,000 bait traps.

Emergency inspection stations were established at Tehachapi, Wheeler Ridge and Los Alamos. They were placed at these points in order to cover the State's north and south highway systems and were later replaced by permanent stations. Temporary sampling stations were also established at points on the highways near San Diego, San Bernardino and Indio to check on possible movement of contraband.

On August 17th and 18th a meeting of the Executive Committee of the Western Plant Board was called in Reno by the chairman to consider

interstate aspects of the moth problem. The principle was formulated that wherever a State would patrol and quarantine known infestations, interstate quarantines would be limited to the actually infested counties; that where no effort was made to protect clean areas, the entire State would be quarantined. The acceptance of treatments in lieu of quarantines was also approved. Oregon and Washington placed embargo quarantines. Both have now been revised to admit treated fruit.

Treatments

The advent of the moth did not find the State unprepared. Tests which had been started in 1937 to measure the tolerance of certain host fruits to the vapors of methyl bromide in anticipation of possible finding of the moth had been successful in destroying the larvae of the codling moth, a related species, in all parts of the fruit and had already become industrialized in the treatment of pears and apples. However, the problem of developing formulae and techniques to meet all conditions and circumstances under which host fruits might be handled has presented a number of obstacles difficult to surmount. The Oriental fruit moth has proven very intolerant to the vapors of methyl bromide. At the summer temperatures met in California, dosages which are completely lethal to the moth can be tolerated by practically all its hosts, and still maintain that safety factor compatible with the security level required where reatment is used in lieu of a quarantine. On the basis of tests carried out, a sliding scale of treatments for fruit, known as a summer schedule, was put into effect between May 1st and October 31st, to be followed by revised schedules for lower winter temperatures as these are developed.

The summer schedules for temperatures over 70° F. are 1½ lbs. of methyl bromide per 1,000 cubic feet for two hours, 2 lbs. from 69° F. to 65° F., inclusive, and 2½ lbs. at 64° F. to 60° F., inclusive.

As the season progressed, the problem of treatment was further complicated through use of used boxes and also by lower autumn temperatures. Due to war conditions, growers of many types of fruits and vegetables are forced to resort to used boxes which at some time might have been used to carry hosts of the moth, thus making each a potential carrier, since the moth has been taken hibernating within boxes. Since produce dealers are not equipped to repack every box of produce bought, they often find it more convenient to fumigate the box and its load in order to escape the necessity of repacking. Increased dosages required under winter temperatures impose new injury hazards, particularly if used indiscriminately. The dosage necessary to effect a complete kill at 50° F. requires more than double the dosage required to effect complete mortality at 70° F. or over. There is a tendency to treat fruit regardless of injury, merely as a matter of convenience, though it has been noticed that due to probable injury there seems to be developing a tendency to fumigate boxes before packing and create a pool of treated boxes.

Fumigation Frames. To standardize fumigation dosages, twenty knock-down frames 10x10x8 feet, which are covered by a 30x30 foot gas-tight tarpaulin, were constructed. This assured a portable chamber with a capacity of 666+ cubic feet which reflects a dosage of 1½ lbs. of

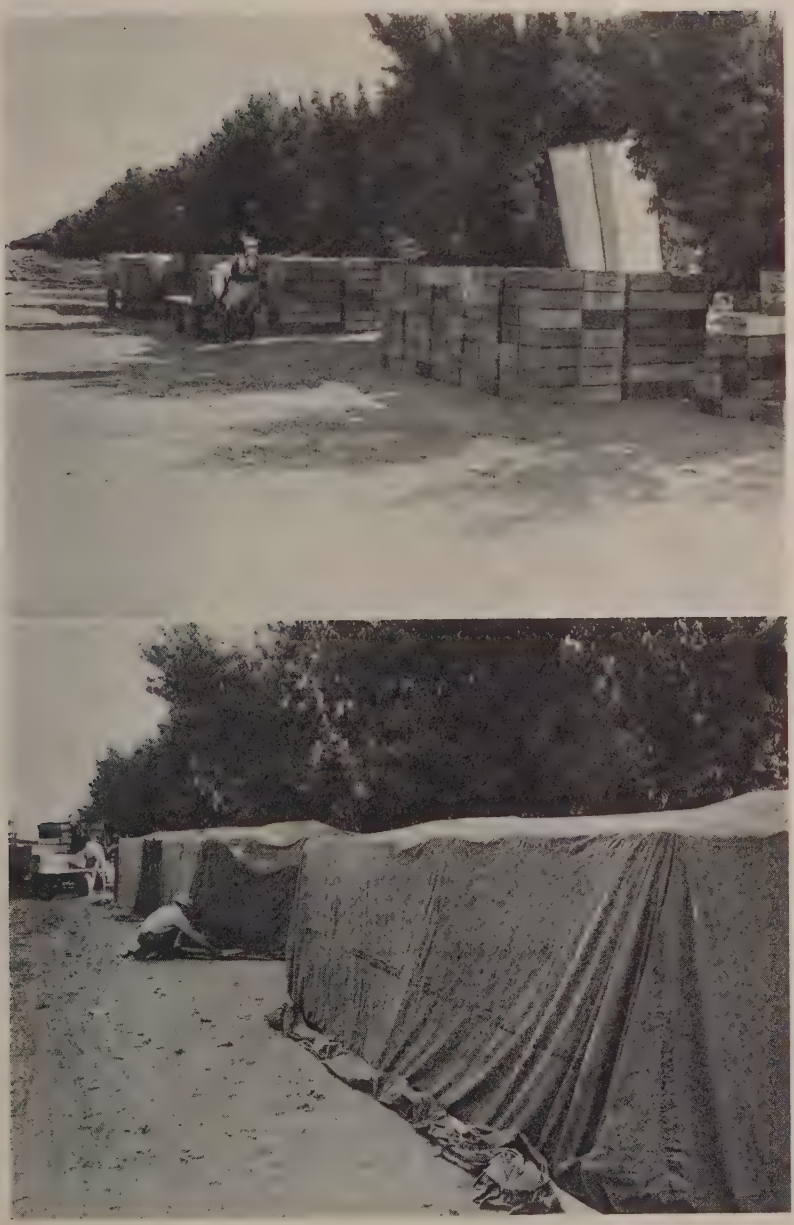


FIG. 2. Top. Stacking boxes prior to fumigation in Kern County.
Lower. Same boxes in process of fumigation.

methyl bromide per 1,000 cubic feet where one pound cans of the fumigant are used, which is standard for summer treatments. It also permits of multiple expansion such as doubling the length where large tarpaulins are available.

Up to October 31st the amount of fruit treated to meet both interstate and intrastate quarantines pertaining to the Oriental fruit moth included 251,922 boxes of host fruit, 120,626 boxes of nonhost fruits and vegetables, and 1,345,036 empty containers. The amount of host fruits treated during the latter months of the year is falling. The higher dosage required to kill has caused some injury to susceptible fruits such as eggplant and cucumbers. Contrary to expectation, injury to bananas has not been reported, though this fruit is known to be intolerant to the vapors of methyl bromide, and considerable amounts were treated.

Practically all fumigation is done under gas-tight tarpaulins. On those ranches and premises under quarantine, the State has done the work gratis and supplied the fumigant. Peaches constitute the bulk of the fruit treated; 69,985 field boxes of 40 pounds each were treated in this manner. Six varieties, including both cling and freestone peaches, were treated. Due to high temperatures most of the work was done in the evening and during the night.

In the case of produce shipments arriving in the wholesale markets of southern California the work was done by commercial fumigators and the cost was paid by the shipper.

Box Sterilizers. A common means of distribution of the moth is by mature larvae spinning cocoons in seams and behind cleats of boxes that have carried host fruit. To destroy any cocoon so located, mechanical box sterilizers, consisting of tunnels piped with steam, are used. In passing through these tunnels the boxes are exposed to temperatures of 170° to 200° F., which are fatal to any insects.

The largest sterilizer of this type consists of 200 feet of tunnel and has a capacity of 30,000 boxes per day (24 hours). This type of sterilizer is an improved version of the original steam sterilizer invented by the writer in 1919.

Eradication

Activities directly chargeable to eradication have been confined to the preparation of legal descriptions of all infested and adjacent properties, setting forth the boundaries of all eradication areas, and a count of all trees, giving age, variety, ownership and other pertinent information that would enable proper appraisal values in event a program of host removal was decided upon.

Hosts of the Moth

Knowledge of the plants that support any species of insect becomes increasingly important wherever control is sought. It becomes a prime necessity where an eradication program is under consideration. This was never truer than in the case of the Oriental fruit moth. Unfortunately records of both native and ornamental species attacked by the moth are exceedingly fragmentary. Records of some States indicate that wild plum thickets serve as a reservoir as it was taken by the writer in twigs of the chickasaw plum, *Prunus angustifolia,* in Georgia in May,

1929. Allison Denning, State Entomologist of Missouri, reports that native plums of that State support a considerable population of the moth in the late summer. The species involved is probably *Prunus americana.* The Japanese photinia, *Photinia serrulata,* is reported as a host in Georgia. It is also reported from Japan.

On the basis of foreign host records supplied by the United States Bureau of Entomology and Plant Quarantine, loquats were placed on the suspicious list and the fruits were early discovered to be a host of the moth.

Research projects dealing with the possible hosts have been organized by the University under direction of A. M. Boyce with R. C. Dickson in charge. Plants under suspicion were tested by placing eggs on the foliage. Ability of the larvae to establish themselves in these plants and to develop thereon constituted the first test. The second step involved observation of the moth on these plants in the state of nature.

Of 417 tests made on twigs or fruits of 80 species of plants, representing 40 families, the Oriental fruit moth was able to complete its development on 11 species not previously reported as hosts. A list of these plants includes nine members of the rose family, one of the persimmon family, and one of the myrtle family.

Two native shrubs used as ornamentals:

1. *Prunus ilicifolia,* Catalina cherry, twigs and fruit
2. *Photinia arbutifolia,* Toyon, twigs

Six introduced trees and shrubs used as ornamentals:

3. *Prunus caroliniana,* Carolina cherry, twigs
4. *Prunus laurocerasus,* English laurel, twigs
5. *Cotoneaster parneyi,* Parney's cotoneaster, twigs
6. *Cotoneaster pannosa,* Silver leaf, twigs and fruits
7. *Photinia serrulata,* Japanese photinia, twigs
8. *Pyracantha formosiana,* Firethorn, fruit

Three fruit trees:

9. *Eriobotrya japonica,* Loquat, twigs and fruit
10. *Diospyros kaki,* Oriental persimmon, fruit
11. *Psidium guajava,* Guava, fruits

Of this list, the first six have been found naturally infested in Orange County.

Twenty-seven plants and 39 families have been found to be nonhosts. These plants or trees, shrubs and vines grown for shade as ornamentals, include Persian walnut, orange, lemon, rose, oleander, prickly pear, eucalyptus, olive and avocado. The moth likewise failed to live on dried prunes, nonsulphured peaches, or oak galls of *Andricus californica.*

The host pattern that seems to be emerging from this work is that the Oriental fruit moth is restricted to certain rosaceous plants when attacking the twigs, but it can also infest some soft fruit of other families.

Federal Cooperation

To obtain a better picture of conditions on the periphery of the general area of known infestation, in October, 1942, the writer asked for and received the cooperation of the United States Bureau of Entomology and Plant Quarantine in a survey of the Rocky Mountain and Pacific Coast States, exclusive of California. Funds were allocated to this project from the appropriation under the Emergency Fund for Control of Incipient Pest Outbreaks. This is the appropriation from which a number of regulatory projects, such as Mormon cricket, grasshopper, chinch bug, pear psylla and other projects, are financed. The Federal survey included 16 States. The survey was largely confined to peaches, a favorite host, and included both twig and trapping surveys. The former was made in 503 counties of 16 western States and the State of Chihuahua, Republic of Mexico; 1,465,020 host trees were inspected.

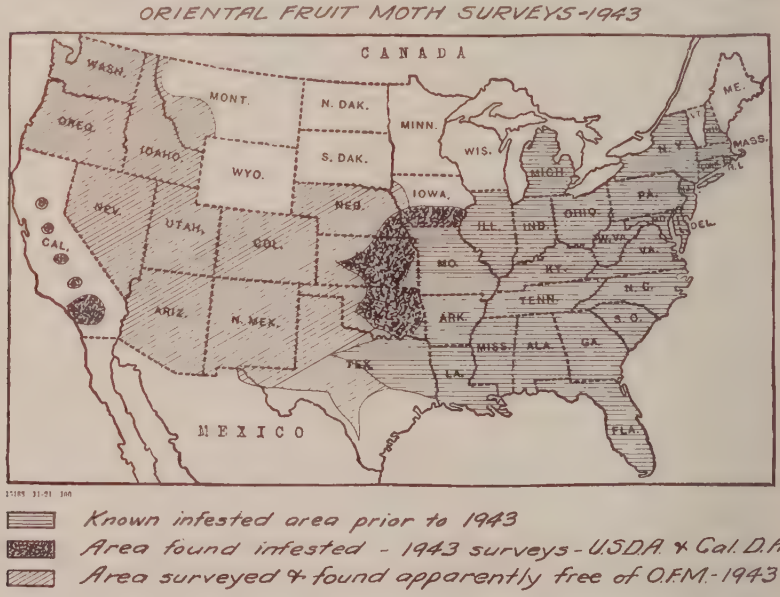


FIG. 3. Map Showing Oriental Fruit in Moth Surveys—1943.

Positive determinations were made from specimens submitted from four counties in Texas, 19 in Oklahoma, 32 in Kansas, six in Nebraska, and nine in Iowa. Incomplete determinations were made from 12 counties in Texas, 11 in Oklahoma, one in Kansas, two in Nebraska and 16 in Iowa. In most cases specimens from these counties were determined as *Grapholitha* sp. and further surveys will be necessary before it can be determined definitely whether or not Oriental fruit moth exists in these localities.

To expedite the development of treatments known to be lethal to all stages of the moth in fruits, the California Department of Agriculture asked the United States Bureau of Entomology and Plant Quarantine to set up a collaborative project to determine the tolerance of host

fruits of the moth to fumigation with methyl bromide under industrial conditions, with special reference to host fruits moving into and out of cold storage. The value of such research lies in the ability of States to provide means to keep markets for host fruit open regardless of where infestation may be found. Providing a means of comparing results obtained under California conditions was the second objective.

California's contribution to the project in question which is set up on a biennial basis and amounts to $8,000 was slightly less than the amount made available by the Federal Government.

Field Observations (California State Department of Agriculture)

Field observations in regard to the moth's actions in commercial plantings of peaches in the major peach growing areas have been limited to close scrutiny of the orchards where adult moths have been trapped and to periods when ripening fruit was on the trees.

The weather was abnormally warm in late February and early March. On March 2d the first Oriental fruit moth emerged in the insectary. Though many moths emerged, there was much delayed foliation of peach trees by reason of the warm weather. Since there was no foliage on which to oviposit, and no new shoots to sustain the larvae, the moths immediately attacked the newly set peaches. A period of very cool weather followed which delayed general emergence of the moth for almost a month.

It is significant that in California where the culture of peaches depends on irrigation for moisture there is a much longer growing season and luxuriant twig growth can be induced even late in the season. In the eastern States this depends on natural rainfall and the twigs harden earlier.

An examination of literature by eastern entomologists indicates that the larvae prefer the succulent tips of growing twigs and infest these as long as they are available. It is reported that in years of normal rainfall the twig growth is able to accommodate the first three generations.

Two observations made at Denair, Stanislaus County, on August 2d, and at Visalia, Tulare County, on September 28th, are of interest. In the first observation an intense inspection of the twigs and fruit in close proximity to the location where the first specimen was trapped showed two larvae in the new growth twigs (of which there was an abundance) and none in the fruit, although several hundred were cut. *Anarsia lineatella* was abundant in these fruits but not in the twigs.

In the second, an inspector assigned to make an intense inspection of the infested and adjacent properties, found, on September 26th, 18 Oriental fruit moth in nectarine twigs on the original infested property. Two larvae were found in the twigs of a flowering peach. None was found in fruit, although there was a heavy crop of small white peaches on the same tree.

The presence of an abundance of new twig growth at this time is reported merely as a circumstance which may be worthy of further study in the relationship of late twig growth to fruit infestations.

Research

In order not to mix research projects with the regulatory aspects of the problem, funds for research have been allocated to the Entomology Department of the University of California. These projects include (1) biological control, (2) chemical control, and (3) studies of the bionomics of the moth under California conditions, and its hosts. The third is divided into two parts, one to be devoted to studies of the moth in the southern part of the State and the other to conditions which prevail in the State's central valleys.

Biological control is under Professor Harry S. Smith, while chemical control is under Professor A. M. Boyce. Projects dealing with the bionomics of the moth are under the direction of A. M. Boyce and E. O. Essig. Research relating to chemical control is centered at Riverside. The biological control laboratories will have their headquarters at Berkeley.

While sufficient time has not elapsed to obtain a picture of the effects of biological control on the behavior pattern of the moth under California conditions, very interesting and informative data rich in promise have been developed during this period of preliminary research.

Biological Control. The outstanding discovery in the field of biological control which marks an entirely new departure is the development of technique which permits the rearing of major parasites of the Oriental fruit moth (*Macrocentrus ancylivorus*) on the larvae of the potato tuber moth, *Gnorimoschema operculella*, which permits the parasites to be reared at any season of the year. The project under way contemplates the production of eight million parasites per season. At frequent intervals these parasites will be liberated in the immediate vicinity of each foci of infestation. The object of such a program is to prevent any build-up of the Oriental fruit moth population, particularly among the early generations. It is also a matter of interest to report that the second most effective parasite, *Glypta rufiscutellaris,* also has been cultured on potato tuber moth.

Chemical Control Studies. Chemical control investigations have been under way for only a few months and while, like biological control, sufficient time has not elapsed to furnish evidence of effectiveness, tests made include inert dusts both with and without mineral oil impregnations, and also dusts with nicotine bases. Fifteen different mixtures have been under test. I am informed that tests have been made with new compounds developed in connection with problems related to the war, some of which are of particular promise. Efficiency in field tests was determined by weekly collections of fruit moth larvae from newly infested peach twigs on count trees. Tests on attractants included bait formulae, types of containers and their arrangement in trees. In this connection 23 aromatic materials were tested. A comparison of types of traps and baits used in California also was made by the United States Bureau of Entomology and Plant Quarantine at its Morristown, New Jersey, station.

Influence of the War Effort

Few entomological activities, particularly those of the nature of the Oriental fruit moth project, can be organized or carried out without taking cognizance of the influence that may be exerted on it at any time

by the Nation's war effort. While these influences may be only transitory in their effects, and since military necessity transcends civilian needs, any forecast of the extent to which these influences will operate is impossible. At any time they may tend to disorganize or even defeat any program which the department may prepare. These influences may be divided into three general categories: (1) manpower, (2) supplies, and (3) transportation, of which the following are examples:

Manpower. The manpower situation is increasingly affected by absorption of departmental personnel into the armed forces. This acute shortage is also reflected in the lack of qualifications of available personnel to carry on the various technical functions of the project. The manpower situation is also vitally affected by the question of housing, particularly for staff members who are in travel status, and where concentrations of men must be established.

Supplies. The significance of this category lies in its promise of the future. The supply shortage is felt all along the line. It is most acute in the field of treatments pertaining to host fruits and other commodities requiring treatment, where treatment is a condition of movement. It includes a long list for which treatments are mandatory to prevent spread of the moth, both interstate and intrastate.

An excellent example is furnished in the recent action of the Government in freezing all stores of methyl bromide, the only fumigant that can be used to treat fresh fruit. At this writing the allocation of this material for use in California is substantially reduced and the uses to which it may be put are limited. The 1944 Oriental fruit moth project indicates greatly increased demand for this fumigant.

A similar situation exists in the matter of securing material and equipment for use in the construction of box sterilizers in canneries where auxiliary steam boilers are needed.

Transportation. The needs of the armed forces of the Country demand a great curtailment in civilian automotive travel. This fact necessitates a radical departure from the established pattern which has characterized the surveys recently completed.

The combined effects of these factors may make it expedient to develop a flexible program that permits of shift in the Oriental fruit moth front, even if these involve a compromise.

Conclusion

Sufficient time has not elapsed to state definitely what the future behavior pattern of the Oriental fruit moth in California will be, hence, for the present and perhaps for some time to come, the department probably will be compelled wherever possible to devote a considerable part of its Oriental fruit moth appropriations and effort to a "holding campaign" to prevent distribution, while the research entomologists develop control methods.

As a result of the surveys conducted during 1943 in 36 counties of the State it becomes increasingly evident that the Oriental fruit moth must be regarded as a permanent resident in California and sooner or later may be expected gradually to spread throughout the State.

Rapidity of distribution will presumably be governed more by human agency than by means of its favorite hosts, though ultimate population density will be governed by host plant association and other ecological factors.

ERIOPHYID STUDIES XIV *

H. H. Keifer
Insect Taxonomy
State Department of Agriculture

The present installment contains the descriptions of ten new species of mites, including a pest of persimmon and a pest of cypress, and a group and generic revision of the family. I feel that the data now on hand discloses certain definite structural groupings by means of which the larger Eriophyid genera can be fairly adequately split into more homogeneous aggregations of species. It is also clear that the possession of anterior setae on the cephalothoracic shield, and of subdorsal abdominal setae, constitutes much more than specific differences from the species that lack these setae. We have, in reality, two different types of setal arrangement present in the Eriophyidae. Each setal group is further characterized by its own type of female genitalia and certain leg features. This is the basis for the following two new subfamilies.

SYNOPSIS OF ERIOPHYID SUBFAMILIES

Three or four setiferous tubercles on shield, the rear pair of tubercles always bearing setae that point forward; anterior pair of subdorsal abdominal setae present or absent; foretibia usually with a lateral spur; hind patellar seta often laterally placed; female coverflap smooth; female genital glands elliptical or elongate, arising from ducts that project forward and then recurve laterally ---------- 1.

One pair of setiferous tubercles on the cephalothoracic shield, or these absent; no subdorsal abdominal setae; no lateral spur on foretibia; hind patellar seta always arising from above; female genital coverflap variously sculptured or smooth; female genital glands usually subcircular and on short lateral or diagonally posteriorly directed ducts originating from rear of genital opening ---------- 2.

1. Shield with no anterior lobe over rostrum; abdomen wormlike with rings similar dorsoventrally ---------- PHYTOPTINAE, new subfamily

1. Shield with an anterior lobe over rostrum which is sometimes very short, abdomen divided laterally into broader tergites, and more numerous narrower sternites ---------- SIERRAPHYTOPTINAE, new subfamily

2. Shield never with lobe overhanging rostrum; abdomen wormlike, with rings similar above and below, at least anteriorly; when rostrum large, not set at right angles to body and with evenly curved chelicerae ---------- ERIOPHYINAE

2. Shield usually with anterior lobe over rostrum; abdomen most often divided laterally into broader tergites and narrower sternites; or with large tapering rostrum, set at right angles to body, and with large chelicerae abruptly downcurved in front of rostrum base ---------- PHYLLOCOPTINAE

PHYTOPTINAE

Phytoptus Dujardin 1851

Dujardin—Ann. Sci. Nat. Paris Zool. (3) Vol. 15, p. 106, 1851
Keifer—Bul. Cal. Dept. Agr. Vol. 27, p. 301, 1938, genotype *avellanae* Nal.

Phytoptus pini Nalepa

Plate 180

Keifer—Bul. Cal. Dept. Agr. Vol. 27, p. 181, June 1938.

The pine needle mite has been refigured from Torrey Pine, *Pinus torreyana* Parry, to show the type of female genitalia in relation to other species in *Phytoptus*. The long-stalked genital glands seem to be characteristic of coniferous infesting Phytoptinae.

* Eriophyid Studies XIII was published in the Bul. Cal. Dept. Agr. Vol. 32, No. 3, p. 212, Oct. 14, 1943. When describing *Eriophyes litchii*, p. 212, XIII, I neglected to note Oudemans' name for this mite: *Eriophyes cordai*, Crit.-Hist. Acar. III, p. 1325, 1937. O'Gara had neither described nor named the mite so the derivation of *chinensis* O'Gara, the original name for this species, is not immediately apparent. However, as my account of the species is the first description, *litchii* K. should stand.

A more thorough study of this mite on various hosts and in the several geographical areas it inhabits, is necessary. I have yet to see pine twig galls in North America similar to those in Europe ascribed to the activities of this mite.

Phytoptus cupressi Keifer, new species

Plate 181

Female 200-260 μ long, 40-50 thick, wormlike, whitish. Rostrum 30 μ long, somewhat downcurved. Shield 27 μ long, 40 μ wide, diagonal lines from rear margin to tubercles; frontal seta 11 μ long; a few lines along side of shield; dorsal tubercles 12 μ apart, well ahead of rear margin; dorsal setae 50 μ long, projecting forward. Forelegs 31 μ long, tibia 6 μ long, tarsus 7 μ long; claw 8 μ long, tapering, curved; featherclaw 7 rayed. Hindlegs 28 μ long, tibia 4.5 μ long, tarsus 7 μ long, claw 8 μ long. Anterior coxae separate. Abdomen with 60-70 rings, completely microtuberculate; microtubercles evenly curved, not pointed. Subdorsal seta 12 μ long, on ring 10. Lateral seta 30 μ long, on about ring 8; first ventral 20 μ long, on about ring 18; second ventral 20 μ long, on about ring 32; third ventral 33 μ long, on about ring 6 from rear; accessory seta present, 20 μ long. Female genitalia with long stalked glands; 21 μ wide, 12 μ long, coverflap smooth, seta 14 μ long.

Male 150 μ or more long, 40 μ thick.

Type locality: San Francisco, California. **Collected**: August 28, 1943, by the writer. **Host**: *Cupressus macrocarpa* Hartw., Monterey Cypress. **Relation to host**: The mites live in the leaf crevices around the twig tips and cause a centrally necrotic terminal enlargement of the green twigs, in which a colony may be found. **Type slide**: so designated, as above. **Paratype slides**: four in number, with the above data. There are also specimens of this same mite, or a very similar species, from *Juniperus chinensis procumbens* Endl. taken in Berkeley, California, October 1, 1941, by M. R. Bell of the State Nursery Service. The mite was killing the twig tips on this juniper. I am unable to identify *cupressi* with *Phytoptus quadrisetus* (Thom.) on the basis of Nalepa's figure of that species.

Setoptus Keifer, new genus

Body elongate, wormlike, somewhat clavate anteriorly. Rostrum large, chelicerae evenly curved. Cephalothoracic shield longer than wide, with broad, transverse front edge and narrower transverse rear edge; three setiferous tubercles, the central anterior set projecting up, the long paired lateral setae projecting forward from tubercles about equidistant from front and rear margins. Legs with all usual setae plus a lateral spur or seta on the foretibia; hind patellar seta somewhat lateral; featherclaw simple. Narrow abdominal rings completely microtuberculate, a shallow sublateral furrow; no subdorsal abdominal setae; the remaining setae in usual positions. Female genitalia with smooth coverflap and long-stalked genital glands.

Genotype: *"Platyphytoptus" jonesi* K.
Bul. Cal. Dept. Agr. Vol. 27, p. 189, 1938

The genotype is the largest Eriophyid yet described, being one-third of a millimeter long. It has a discontinuous distribution along the California coast. M. L. Jones collected the original specimens from Torrey Pines growing in their native stand on the bluffs above the San Diego County beaches. I have examined native Monterey Pines, *Pinus radiata* Don., both on the Monterey peninsula and at Año Nuevo Point (San Mateo County) without finding *Setoptus jonesi*. However, the mite reappears on Biship pine, *Pinus muricata* Don., north of the above listed localities near Point Reyes at Inverness, California, a native stand of Bishop pine. *Setoptus* differs from *Phytoptus* in lacking subdorsal abdominal setae and in the sublateral furrow. The name is a contraction of *Seta* plus *Phytoptus*.

As I have not seen either *Phytoptus quadrisetus* (Thom.) or *Phytoptus abnormis* (Gar.), I am not including them in the following synopsis.

SYNOPSIS OF THE PHYTOPTINAE

A sublateral longitudinal abdominal furrow; subdorsal abdominal setae missing; rostrum very large; shield with transverse rear edge; in needle sheaths of *Pinus torreyana* and *muricata*----------SETOPTUS JONESI K.

Abdomen cylindrical in cross section; subdorsal abdominal setae present; rostrum moderate in size; shield curved posteriorly (PHYTOPTUS)----------1

1. Three cephalothoracic shield setae; female genital glands long-stalked; on conifers----------2

1. Four setiferous tubercles on shield; female genital glands short-stalked----------3

2. Anterior shield seta minute; subdorsal abdominal setae short; in pine needle sheaths----------PINI Nal.

2. Anterior shield seta and subdorsal setae of moderate length; in swollen tips on cypress----------CUPRESSI K.

3. Foretibia lacking a lateral spur; causing filbert "big-bud"----AVELLANAE Nal.

3. Foretibia possessing a lateral spur;----------4

4. Shield smooth; in buds and among seeds on *Cornus* spp.----------CORNISEMINIS K.

4. Shield with a design of longitudinal ridges; in *Hedera* buds, causing twig stunting----------HEDERAE K.

SIERRAPHYTOPTINAE

Austracus Keifer, new genus

Body wormlike, cylindrical in cross-section, curved. Rostrum moderate in size. Shield subtriangular, scarcely overhanging rostrum anteriorly; four setiferous tubercles present, laterally placed in anterior and posterior pairs, the posterior tubercles somewhat ahead of the rear margin and directing the setae ahead and outward. Legs with all usual setae, plus a lateral spur on the foretibia and the hind patellar seta laterally placed. Abdomen with broad fairly smooth tergites; sternites much more numerous, microtuberculate; a pair of anterior subdorsal setae present; the other setae in the usual positions. Female genitalia with smooth coverflap; glands gradually enlarging from anteriorly projecting recurved ducts.

Genotype: *Austracus havrylenkonis*, new species

This genus is characterized by the shield and body shape, and by the subdorsal abdominal setae. The name is *Austral* plus *acus* for *Acarus*.

Austracus havrylenkonis Keifer, new species

Plate 182

Female 200-275 μ long, 50-70 μ thick, robust, wormlike. Rostrum 23 μ long, somewhat downcurved; apical seta 4.5 μ long. Shield 30 μ long, 43 μ wide, without apparent design; no anterior lobe, dorsal tubercles 18 μ apart, ahead of rear margin; dorsal setae 11 μ long, pointing forward; anterior tubercles 20 μ apart; anterior setae 7 μ long, pointing diagonally outward. Forelegs 38 μ long, tibia 8 μ long, with a lateral spur, tarsus 8 μ long, claw 8.5 μ long, somewhat curved; featherclaw 4 rayed. Hindlegs 35 μ long, patellar seta lateral, tibia 6.5 μ long, tarsus 7.5 μ long, claw 9 μ long. Coxae with strong sternal line. Abdomen with subdorsal seta on second tergite, about 40 μ long; tergites non-tuberculate, ridged at rear margin; sternites set with oval microtubercles; 16-18 tergites; about 50 sternites, lateral setae 9 μ long, on about sternite 7; first ventral 14 μ long, on about sternite 19; second ventral 11.5 μ long, on about sternite 28, third ventral 25 μ long, on about sternite 4 from rear; accessory seta present. Female genitalia 23 μ wide, 16 μ long, coverflap with none of the usual furrows, but a basal and apical division, seta 8 μ long.

Male: 200-230 μ long, 50-60 μ thick.

Type locality: Isla Victoria, Nahuel Huapi National Park, Argentina. **Collected:** April, 1943, by D. Havrylenko. **Host:** *Nothofagus dombeyi* of the Fagaceae. **Relation to host:** Causing a gall in the fruit. **Type slide:** with the above data. **Paratype slides:** four in number as above. I take pleasure in naming this unusual Eriophyid for the collector. The fact that *Austracus havrylenkonis* and *Sierraphytoptus alnivagrans* have subdorsal abdominal setae greatly influenced the erection of the two new subfamilies at the beginning of this paper. No mite with these setae and broad tergites has been found outside the western hemisphere. The very short shield lobe over the rostrum may be degeneration due to the gall-forming habit.

Nalepella Keifer, new genus

Body spindleform. Rostrum moderate in size. Shield subtriangular, anterior lobe over rostrum; three setiferous tubercles, one on anterior lobe; paired rear tubercles well ahead of rear margin and directing long setae ahead. Legs presumably with all usual setae, hind patellar seta apparently placed laterally, featherclaw simple. Abdomen with non-tuberculate tergites less numerous than the microtuberculate sternites; subdorsal abdominal setae absent, the other setae in usual locations. Female genitalia not described.

Genotype: *Phyllocoptes triceras* Börner

Börner—Abr. Biol. Abt. Land-Forster. Kaiserl. Gesundt Berlin Vol. 5, p. 140, 1906
Nalepa—Marcellia Vol. 25, p. 70, 1929

While I have not seen anything like this species, the original description bears a creditable lateral diagram by Börner. The position and direction of the large paired shield setae harmonize with other mites bearing extra setae. The figure is evasive about the exact location of the anterior shield setae and aside from the lateral hind patellar seta leaves the legs and female genitalia to be investigated. But it is necessary to designate a new genus for *triceras* to fit it into the present classification scheme. The mite is said to be a vagrant on the needles of *Pinus veitchi* Lindl. The generic name, *Nalepella* is for the well-known Austrian Eriophyidologist.

SYNOPSIS OF SIERRAPHYTOPTINE GENERA

Subdorsal abdominal setae present 1
Subdorsal abdominal setae absent 2

1. Shield with an anterior lobe over rostrum; body broad, flattened ..... SIERRAPHYTOPTUS K.
1. Shield hardly overhanging rostrum; body more wormlike ..... AUSTRACUS K.
2. Two anterior shield setae present; body elongate with longitudinal lines on broad tergites ..... MACKIELLA K.
2. One anterior shield seta; body spindleform, the tergites narrower and lacking lines ..... NALEPELLA K.

ERIOPHYINAE

Eriophyes von Siebold 1851

The type of this genus as set by me in 1938 is *Eriophyes vitis* Pgst. (Bul. Cal. Dept. Agr. Vol. 27, p. 301). This mite, as well as possessing the usual Eriophyine features, is characterized by paired setiferous shield tubercles a little ahead of the rear shield margin which direct the setae ahead and centrad; female genitalia somewhat appressed to the coxae which are spread more than usual; female coverflap longitudinally furrowed, the furrows tending to be two-ranked; female anterior genital apodeme much shortened in ventral view. I here propose to divide the mass of species referred to *Eriophyes* (*Phytoptus*—old use) into three groups, mainly on the presence and position of the dorsal tubercles, or their absence. Thus *Eriophyes* will hereafter be used for mites with dorsal tubercles more or less ahead of the rear shield margin, that are so inclined as to direct the setae ahead or centrad. All of the species I have studied with such a character, aside from the genotype, have female genitalia a normal distance behind the coxae, the coverflap furrows when present are in one line, and the apodeme is of normal length. Thus the genotype is at once unharmonious with the bulk of species herein referred to *Eriophyes* and may have to be separated. The interspecific variation of the dorsal tubercle position suggests further heterogeneity. The other two groups which are apparently quite homogeneous will be discussed in turn.

Eriophyes vitis Pgst.

Plate 183

Pagenstecher—Verh. nat.—med. Ver. Heidelburg, Vol. 1, p. 46-53, 1857-59
Landois—Zeitsch. Wiss. Zool. Vol. 14, p. 353, 1864
Parrott, Hodgkiss, Schoene—N. Y. Agr. Exp. Sta. Bul. 283, p. 289, 1906
Banks—Proc. U.S.N.M., Vol. 32, p. 621, 1907
Nalepa—Marcellia, Vol. 25, p. 125, 1929.

Female 160-200 μ long, 40 μ thick, wormlike, pale yellowish. Rostrum 21 μ long, curved down. Shield 27 μ long, 32 μ wide, blunt, triangular, numerous longitudinal lines, an ocellus-like lateral spot; dorsal tubercles 15 μ apart, ahead of rear margin; dorsal setae 18 μ long, projecting ahead and centrad. Forelegs 30 μ long, tibia 7 μ long, tarsus 8 μ long, claw 8 μ long, tapering; featherclaw 5 rayed. Hindlegs 26 μ

long, tibia 4 μ long, tarsus 7 μ long, claw 10.5 μ long. Coxae with setae I ahead of junction of anterior coxae; setae II ahead of line through setae III. Abdomen with 65-70 rings, completely microtuberculate, the microtubercles slightly pointed. Lateral seta 19 μ long, on about ring 7; first ventral 38 μ long, on about ring 22; second ventral 42 μ long, on about ring 40; third ventral 15.5 μ long, on about ring 4 from rear; accessory seta missing. Female genitalia somewhat appressed to hind coxae, the anterior apodeme shortened in ventral view; 20 μ wide, 10 μ long, coverflap with 16 or more furrows, interrupted across center; seta 14 μ long.

Male 140-160 μ long, 35 μ thick.

Locality: Fresno district, California. **Collected**: June 1943 by Dr. E. M. Stafford. **Host**: *Vitis vinifera* L., grape, Vitaceae. **Relation to host**: The mites cause extensive undersurface white erineum on the leaves. They overwinter in the buds and may do early spring damage to young shoots. *Eriophyes vitis* is generally distributed in the California grape-growing sections, but the erineum cannot be found everywhere. Further study of hosts and economic importance of this mite is needed. *Eriophyes vitis* is generally distributed in Europe and elsewhere.

Eriophyes caricis Keifer, new species

Plate 184

Female 150-180 μ long, 40 μ thick, somewhat clavate anteriorly, flattened, whitish. Rostrum 26 μ long, curved down, apical seta rather short. Shield 40 μ long, 38 μ wide; a pattern of lines centrally, the sides quite granular; dorsal tubercles 17.5 μ apart, well ahead of rear margin. Dorsal setae 10 μ long, directed up and centrad. Forelegs 34 μ long, tibia 7.5 μ long, tarsus 7 μ long; claw 8 μ long, curved, tapering; featherclaw 6 rayed. Hindlegs 30 μ long, tibia 6 μ long, tarsus 6.5 μ long, claw 9.5 μ long. Anterior coxae not clearly touching, nor any sternal line present. Abdomen with 80-90 rings, the rings microtuberculate and some dorsad reduction in ring number. Lateral seta 38 μ long, on about ring 10; first ventral 50 μ long, on about ring 27; second ventral 14 μ long, on about ring 48; third ventral 28 μ long, on about ring 7 from rear; accessory seta present. Female genitalia 23 μ wide, 17 μ long, coverflap with about 12 furrows, seta 12 μ long.

Male 140 μ long; 40 μ thick.

Type locality: Sacramento, California. **Collected**: September 19 and 30, 1943 by the writer. **Host**: *Carex barbarae* Dew., sedge, Cyperaceae. **Relation to host**: The mites are found down in the plant toward the base of the leaves where the tissue is turning from yellow to green. No damage was noted. **Type slide**: so designated, with the above data and dated September 19. **Paratype slides**: five in number as above. The position of the dorsal tubercles is not similar to *Eriophyes vitis*, though ahead of the rear margin.

I intend to publish a list of species in the next installment, showing which are assigned to *Eriophyes*, and which to the other genera, here proposed. The pear leaf blister mite, *pyri* Pgst., goes into *Eriophyes*, but the citrus bud mite, *sheldoni* Ewing, is associated with the following genus.

Aceria Keifer, new genus

Body wormlike, circular in cross section or nearly so. Rostrum various in size, usually small, when large with the chelicerae evenly curved. Shield usually subtriangular, dorsal setiferous paired tubercles, in subdorsal positions on rear shield margin and directing the setae caudad. Legs with all usual setae and simple featherclaw. Abdominal rings the same above and below, usually more numerous dorsally, nearly always microtuberculate. Female genitalia a moderate distance behind coxae; coverflap furrowed or smooth, usually with a single row of longitudinal scoring; anterior female apodeme of normal length in ventral view.

Genotype: *Eriophyes tulipae* Keifer
Bul. Cal. Dept. Agr. Vol. 27, p. 185, 1938.

Aceria is separated from Eriophyes by the dorsal setiferous tubercles being on the rear shield margin and directing the setae caudad. This is the largest genus in the family, possessing many series of closely related species. It appears to be homogeneous. The walnut mites with smooth

coverflap and triradiate featherclaws are the most unharmonious species known and they are connected via the oak mites. The peculiar mites referable to *Paraphytoptus*, that have an abdomen which is Eriophyine anteriorly and "Phyllocoptine" posteriorly are definitely connected here. The intergrades between *Aceria* and *Paraphytoptus* may make an arbitrary division point necessary. The name, *Aceria*, is composed of the first two letters of *Acarus*, plus the first part of *Eriophyes*.

Aceria diospyri Keifer, new species

Plate 185

Female 140-170 μ long, 30 μ thick, wormlike, light yellowish white. Rostrum 20 μ long, somewhat downcurved, apical seta short. Shield 24 μ long, 26 μ wide, design a series of longitudinal dotted lines, sides granular; dorsal tubercles 17.5 μ apart, on rear margin; dorsal setae 16 μ long, projecting backwards. Forelegs 20 μ long, tibia 4 μ long, tarsus 4 μ long, claw 6 μ long, somewhat tapering, featherclaw 5 rayed. Hindlegs 20 μ long, tibia 4 μ long, tarsus 4 μ long, claw 7 μ long. Coxae microtuberculate, no definite sternal line. Abdomen with about 70 rings, rings showing ventrad reduction in number, the microtubercles not pointed. Lateral seta 12 μ long, on about ring 7; first ventral 40 μ long, on about ring 22; second ventral minute, on about ring 40; third ventral 13 μ long, on about ring 6 from rear; accessory seta present. Female genitalia 17.5 μ wide, 11.5 μ long, coverflap with 12-14 furrows, seta 8 μ long.

Male not studied.

Type locality: Garden Grove, Orange County, California. **Collected:** October 13, 1943 by E. A. Dudley. **Host:** *Diospyros kaki* Linn., persimmon, of the Ebenaceae. **Relation to host:** The mites develop under the bud scales and under the fruit buttons. In the latter location they blacken the stem end of the fruit and aid premature dropping. **Type slide:** so designated, with the above data. **Paratype slides:** five in number, all from Orange County; one as above, two from Santa Ana, September 20, E. C. Knight; two from San Juan Capistrano, October 8, R. J. Bumgardner. This mite is much like *Aceria sheldoni* (Ewing), the citrus budmite, in both appearance and habit. But *diospyri* has a differently and more clearly designed shield, and shorter setae; the second ventral seta on *diospyri* is minute, whereas it is of appreciable length in *sheldoni*.

Aceria escalloniae Keifer, new species

Plate 186

Female 160-190 μ long, 50 μ thick, wormlike but rather stout. Rostrum 18 μ long, downcurved, apical seta 8 μ long. Shield 32 μ long, 38 μ wide, three central longitudinal lines, granular laterally; dorsal tubercles 30 μ apart, on rear margin; dorsal setae 35 μ long, projecting caudad. Forelegs 32 μ long, tibia 7.5 μ long, claw 8 μ long, curved, slightly knobbed; featherclaw 4 rayed. Hindlegs 31 μ long, tibia 6 μ long, tarsus 7 μ long, claw 8.5 μ long. Anterior coxae touching; tubercles of setae I well ahead of a line through tubercles of setae II. Abdomen with about 60-65 rings, some ventrad reduction in ring number; rings entirely microtuberculate, the tubercles somewhat pointed. Lateral seta 30 μ long, on about ring 10; first ventral 32 μ long, on about ring 23; second ventral 11.5 μ long, on about ring 38; third ventral 24 μ long, on about ring 5 from rear; accessory seta present. Female genitalia 20 μ wide, 14 μ long, coverflap with about 8 longitudinal furrows, seta 14 μ long.

Male 130 μ long, 50 μ thick.

Type locality: Isla Victoria, Nahuel Haupi National Park, Argentina. **Collected:** April, 1943 by D. Haveylenko. **Host:** *Escallonia rubra* Pers., Saxifragaceae. **Relation to host:** The mites deform the fruits, living within the gall. **Type slide:** so designated, with the above data. **Paratype slides:** five in number as above. The four-rayed featherclaw and the two central longitudinal shield lines characterize this mite.

Cecidophyes Nalepa 1889

Nalepa—Sitz. Akad. Wiss. math-natur. Wien. Vol. 98, p. 31, 1889
Nalepa—Denkr. Akad. Wiss. math-natur. Wien. Vol. 59, p. 539, 1892
Keifer—Bul. Cal. Dept. Agr. Vol. 27, p. 302, 1938 genotype *galii* Karp.

The genotype which I designated for this in 1938 is *galii* Karp. I have not seen this species but Nalepa's figure suggests it has all of the following characters which are taken from other species that also lack dorsal tubercles. As well as having the usual Eriophyine features, the mites of this genus lack setiferous tubercles on the cephalothoracic shield; all other setae as usual; female genitalia appressed to the spread rear coxae; female coverflap longitudinally furrowed, the furrows tending to be two-ranked; anterior female apodeme much shortened in ventral view. Nalepa utilized this name for a few years, attempting to group chunky spindleform species under it. He disregarded the setal characters. As I here define *Cecidophyes*, it is a homogeneous group of a few species. If mites are subsequently found lacking dorsal tubercles but possessing female genitalia as described for *Aceria*, they will not be properly referred to *Cecidophyes*. I do not know of any species of this genus native to the Western Hemisphere.

Cecidophyes vermiformis (Nal.)

Plate 187

Nalepa—Sitzb. Akad Wiss math-natur Wien Vol. 98, p. 18, 1889
Nalepa—Marcellia Vol. 25, p. 81, 1929

Female up to 230 μ long, 40 μ thick, light yellowish, elongate-wormlike. The measurements of the 230 μ size are: Rostrum 21 μ long, somewhat downcurved, apical seta 4 μ long. Shield 35 μ long, 35 μ wide, design of numerous longitudinal lines and microtubercles, granulate laterally; dorsal tubercles and setae missing. Forelegs 29 μ long, tibia 6 μ long, tarsus 6.5 μ long, claw 5 μ long, curved; featherclaw 5 rayed. Hindlegs 25 μ long, tibia 5 μ long, tarsus 5 μ long, claw 7 μ long. Coxae somewhat ornamented with curved lines, a thin sternal line present. Abdomen with about 80 rings, some ventrad reduction in ring number; microtubercles pointed. Lateral seta 11 μ long, on about ring 4; first ventral 40 μ long, on about ring 21; second ventral 8 μ long, on about ring 36; third ventral 19 μ long, on about ring 6 from rear; accessory seta absent. Female genitalia with apodeme shortened in ventral view; 23 μ wide, 10 μ long, coverflap with 14-16 furrows and transverse basal lines; seta 10 μ long.

Male not seen.

Locality: Springfield, Oregon. **Collected**: March 21, 1941 by B. G. Thompson. **Host**: *Corylus avellana* L., filbert, *Deviana* variety, Corylaceae. **Relation to host**: The mites are inquilins in the terminal big buds caused by *Phytoptus avellanae* Nal. This is the first record of *vermiformis* from North America. It is widely distributed in Europe, both on filbert and birch. Students will note that *vermiformis* was described in the same paper as *Cecidophyes*, but was placed in *Phytoptus* (old use).

KEY TO ERIOPHYINE GENERA

Abdomen with a median dorsal longitudinal furrow, (dorsal tubercles ahead of rear margin) ---------- MONOCHETUS Nal.
Abdomen with several dorsal longitudinal furrows ---------- PHYTOPTOCHETUS Nal.
Abdomen subcircular in cross section ---------- 1.

1. Abdominal microtubercles bearing one or two recumbent hairs ---------- TRICHOSTIGMA Gerber
1. Microtubercles often spine-like but not bearing hair-like structures ---------- 2.
2. Dorsal setiferous shield tubercles and setae missing; female genitalia appressed to coxae, furrows tending to be in two ranks, apodeme shortened ---------- CECIDOPHYES Nal.
2. Dorsal setiferous tubercles present ---------- 3.
3. Dorsal tubercles more or less ahead of rear shield margin and directing setae ahead or centrad; female genitalia usually a moderate distance from coxae, coverflap smooth or furrows in one row, female genital apodeme of moderate length; female genitalia rarely as in *Cecidophyes* ---------- ERIOPHYES Von S.
3. Dorsal tubercles on rear shield margin and directing setae caudad; female genitalia a moderate distance from coxae, coverflap with furrows in one row, or curved, or coverflap smooth; anterior female genital apodeme of normal length ---------- 4.
4. Abdominal rings similar dorsoventrally for entire abdominal length or but little broadened and reduced in number on posterior dorsum ---------- ACERIA K.
4. Abdominal rings narrow anteriorly but at some point before the distal third becoming increasingly broader dorsally and reduced in number compared to sternites ---------- PARAPHYTOPTUS Nal.

PHYLLOCOPTINAE

KEY TO THE PHYLLOCOPTINE TRIBES

Rostrum variable in size, usually small, when large not set at right angles to body and with chelicerae evenly curved; dorsal setiferous shield tubercles usually present and variable in location, less often directing setae ahead_____PHYLLOCOPTINI

Rostrum large, tapering, set at right angles to body; chelicerae large, projecting directly ahead in front of rostrum base, then abruptly downcurved to the attenuate rostrum apex; dorsal setiferous shield tubercles present or absent, when present located near rear of shield margin and so inclined as to direct the setae forward_____ DIPTILOMIOPINI

PHYLLOCOPTINI

Phyllocoptes Nalepa, 1889

Nalepa—Sitz. Akad. Wiss. math-natur. Wien, Vol. 98, p. 148, 1889
Keifer—Bul. Cal. Dept. Agr. Vol. 27, p. 191, 1938, *carpini* Nal. set as genotype

Phyllocoptes carpini has the dorsal setiferous tubercles placed well ahead of the rear shield margin; abdominal tergites broader and fewer than the sternites; female genitalia a moderate distance from the coxae, smooth coverflap. The anterior female genital apodeme is presumably of the normal length. Thus *carpini* associates the name *Phyllocoptes* with Phyllocoptine species having dorsal tubercles ahead of the rear shield margin. This is comparable to the restriction of similarly tuberculate Eriophyines to *Eriophyes*.

Phyllocoptes calisalicis Keifer, new species

Plate 188

Female 130-170 μ long, 40-45 μ thick, robust, spindleform, reddish. Rostrum 35 μ long, large, tapering, curved down, apical seta 5 μ long. Shield 40 μ long, 35 μ wide, rounded anteriorly and with a narrow sagittate lobe over rostrum; design in center obscurely lined, lateral granulations; dorsal tubercles 19 μ apart, set a little ahead of rear margin and inclined forward; dorsal setae 26 μ long, projecting forward and centrad. Forelegs 32 μ long, tibia 8 μ long, tarsus 7.5 μ long; claw 7 μ long, curved, slightly knobbed; featherclaw 3 rayed. Hindlegs 30 μ long, tibia 6 μ long, tarsus 7.5 μ long, claw 8 μ long. Coxae granular, a moderately long sternal line at junction of forecoxae. Abdomen Eriophyiform, with about 55 microtuberculate rings; ventrad reduction in ring number; microtubercles rounded. Lateral seta 24 μ long, on about sternite 4; first ventral seta 35 μ long, on about sternite 18; second ventral 10.5 μ long, on about sternite 32; third ventral 23 μ long, on sternite 5 from rear; accessory seta present. Female genitalia rather broad, transverse lines and granulations at base of coverflap, the genitalia 20 μ wide, 11 μ long, coverflap with about 16 longitudinal furrows, seta 15 μ long.

Male 130-160 μ long, about 40 μ thick.

Type locality: Sacramento, Cal. **Collected**: Oct. 22, 25, 28, and Nov. 2, 1943, by the writer. **Host**: *Salix spp.* including *S. babylonica* L., weeping willow. **Relation to host**: The mites live behind the lateral buds and at the petiole bases, causing some shriveling to the tissue on which they feed. **Type slide**: so designated, with the above data, host *S. babylonica*, and dated Nov. 2, 1943. **Paratype slides**: five in number, with the above data. If it were not for the peculiar narrow anterior lobe over the rostrum, this mite would fit in *Eriophyes*. But since the immature stages of *Phyllocoptes* are Eriophyiform, and since this new species has degenerated to the *Eriophyes* habit of living concealed on its host, it can be presumed that the abdomen has ceased to develop as far as the normal *Phyllocoptes* species.

Vasates Shimer, 1869

Shimer—Tr. Amer. Ent. Soc. Vol. 2, p. 319, 1869
Hodgkiss—N. Y. Agr. Exp. Sta. Tech. Bul. 163, p. 16, 1930

Vasates quadripedes Shimer is the genotype. According to the description of this species and the figure in the above reference by Hodgkiss, *quadripedes* is a typical Phyllocoptine with an anterior shield lobe over the rostrum, and with smooth tergites about half as numerous as the microtuberculate sternites. The dorsal shield tubercles are on the rear shield margin, directing the setae caudad; the female genitalia are a moderate distance behind the coxae, the coverflap is smooth. Hodgkiss' figure

seems to show the anterior female genital apodeme as of moderate length. The species group then typed by *quadripedes* is similar to *Aceria* in regard to the dorsal tubercles. The majority of species here referred to *Vasates* have the female coverflap scored in one transverse row.

Vasates quadripedes Shimer is a gallmite, forming so-called bladder galls on sugar maple leaves and on one or two other species of maple. Most of the generically associated species are silver mites or leaf vagrants. From the data presented by Hodgkiss it seems probable that *quadripedes* is deuterogynous.

Vasates mckenziei Keifer, new species

Plate 189

Female 170-210 μ long, 40-50 μ thick, wormlike, white; in life covered with white powdery wax. Rostrum 35 μ long, large, downcurved, apical seta 12 μ long. Shield 46 μ long, 40 μ wide, the anterior lobe narrow and pointed; design of longitudinal lines curved to the rear; granules to the rear and sides. Dorsal tubercles 25 μ apart, on rear shield margin; dorsal setae 43 μ long, projecting caudad. Forelegs 36 μ long, tibia 9 μ long, tarsus 10 μ long; claw 11 μ long, curved, tapering; featherclaw 7-rayed. Hindlegs 33 μ long, tibia 6 μ long, tarsus 8.5 μ long, claw 12 μ long. Anterior coxae broadly contiguous; setae I opposite anterior point of junction. Abdomen completely microtuberculate and Eriophyiform, with the sternites slightly more numerous; microtubercles acuminate; sternites about 65 in number. Lateral seta 30 μ long, on about sternite 9; first ventral 52 μ long, on about sternite 23; second ventral 26 μ long, on about sternite 39; third ventral about 25 μ long, on about sternite 5 from rear; accessory seta present. Female genitalia 23 μ wide, 17.5 μ long, coverflap with about 12 long furrows, seta 25 μ long.

Male 150-170 μ long, 35-40 μ thick.

Type locality: Sacramento, Cal. **Collected**: Oct. 3 and 18, 1943, by H. L. McKenzie and the writer. **Host**: *Elymus triticoides* Buckl., wild rye, family Gramineae. **Relation to host**: The mites live in the longitudinal leaf furrows on the upper leaf surface. They apparently cause some leaf browning. **Type slide**: so designated and dated Oct. 18. **Paratype slides**: five in number as above. I take pleasure in naming this mite for Howard L. McKenzie, who took part in collecting specimens. This is another species of Phyllocoptine mite with an Eriophyiform abdomen.

Coptophylla Keifer, new genus

Body generally spindleform, circular in cross section. Rostrum moderate in size. Cephalothoracic shield subtriangular, with anterior lobe over rostrum; dorsal setiferous tubercles and setae missing. Legs with usual setae, featherclaw simple. Abdomen variable: either with broad smooth tergites and more numerous microtuberculate sternites, or with Eriophyiform abdomen. Female genitalia somewhat appressed to the coxae which are separated posteriorly more than usual; coverflap with longitudinal furrows tending to be two-ranked; anterior female genital apodeme much shortened in ventral view.

Genotype: *Phyllocoptes lamimani* Keifer
Bul. Cal. Dept. Agr. Vol. 28, p. 419, 1939

Coptophylla is segregated from both *Phyllocoptes* and *Vasates* by the lack of dorsal tubercles and setae, and by the appressed female genitalia with shortened apodeme. This genus corresponds to *Cecidophyes* and completes the curious parallel between the *Eriophyes-Aceria-Cecidophyes* group and the *Phyllocoptes-Vasates-Coptophylla* group respectively. If this is parallelism, Eriophyid taxonomy is correct. If this is true relationship, this taxonomy is based on the wrong characters. *Coptophylla* is *Phyllocoptes* reversed.

Coptophylla caliquerci Keifer, new species

Plate 190

Female 150-160 μ long, 45-50 μ thick, spindleform, robust, light purple in color. Rostrum 24 μ long, projecting obliquely down, apical seta 8.5 μ long. Shield 38 μ long, 43 μ wide, the anterior lobe broad and short; design a network of dotted lines. Dorsal tubercles and setae absent. Forelegs 34 μ long, tibia 8.5 μ long, tarsus 8.5 μ long;

claw 7 μ long, curved, with small knob; featherclaw 5-rayed. Hindlegs 32 μ long, tibia 6.5 μ long, tarsus 8 μ long, claw 8 μ long. Anterior coxae narrowly contiguous; hind coxae rather widely separated. Abdomen Eriophyiform, completely microtuberculate, the microtubercles pointed; about 48 to 55 rings, the sternites slightly more numerous. Lateral seta 14 μ long, on about sternite 5; first ventral 50 μ long, on about sternite 18; second ventral 11 μ long, on about sternite 30; third ventral 25 μ long, on about sternite 6 from rear; accessory seta absent. Female genitalia 24 μ wide, 12 μ long, coverflap with 15-20 irregular double-ranked furrows; seta 12 μ long.

Male 140 μ long, 40 μ thick.

Type locality: Sacramento, Cal. **Collected:** Sept. 9, 1943 by the writer. **Host:** *Quercus lobata* Nee, Valley white oak, Fagaceae. **Relation to host:** The mites are upper surface vagrants, appearing in late summer. **Type slide:** so designated, with the above data. **Paratype slides:** four in number as above. This mite is very similar to *Coptophylla arbuti* (K), but has a different type of shield ornamentation.

Thamnacus Keifer, new genus

Body somewhat spindleform. Rostrum of moderate size. Shield more nearly semicircular in dorsal view, the lobe over the rostrum rather broad and blunt; dorsal tubercles on rear margin, setae directed caudad. Legs with setae as usual, featherclaw simple. Abdomen with broad smooth tergites and fine microtuberculate sternites; tergites formed into lateral longitudinal troughs on either side of broad evenly arched dorsal elevation; abdominal setae as usual. Female genitalia a moderate distance from coxae, the coverflap with one row of furrows; apodeme of normal length.

Genotype: *Phyllocoptes rhamnicola* K.
Bul. Cal. Dept. of Agr. Vol. 27, p. 307, 1938

This mite would be referred to *Vasates* but the broad dorsal ridge, flanked by furrows, does not fit. *Tegonotus* has a central longitudinal ridge which is acute and therefore not similar to *Thamnacus*. The genotype deforms the leaves of *Rhamnus californicus* at about 3000-5000 feet elevations in the Sierra Nevada Mountains. The name is *Thamnos* plus a contraction of *Acarus*.

Tetra Keifer, new genus

Body spindleform, somewhat dorsoventrally flattened. Rostrum rather small. Shield subtriangular, a small lobe over rostrum; dorsal tubercles on rear margin and directing the long setae caudad. Legs with all usual setae, featherclaw simple. Abdomen with broad non-tuberculate tergites, and narrow microtuberculate sternites; tergites irregular in height and forming a broad dorsal longitudinal trough with a lateral ridge on each side; all setae as usual. Female genitalia a moderate distance from coxae, coverflap with one row of longitudinal scoring; apodeme of normal length in ventral view.

Genotype: *"Phyllocoptruta" concava* K.
Bul. Cal. Dept. of Agr. Vol. 28, p. 489, 1939

This new genus removes *concava* from association with *Phyllocoptruta oleivorus* (Ashm.), the citrus rust mite, with which it does not belong. *Tetra* has the setiferous shield tubercles on the rear margin, directing the long setae backwards, whereas *Phyllocoptruta* has these tubercles well ahead of the rear shield margin and directing the setae up and inward.

Calepitrimerus andropogonis Keifer, new species

Plate 191

Female 160-170 μ long, 50 μ wide, 45 μ thick, flattened spindleform, yellow-orange in color; in life with three tufted rows of yellow wax on the shield and abdominal dorsum. Rostrum 23 μ long, projecting down, apical seta 11 μ long. Shield 55 μ long, 50 μ wide, triangular, anterior lobe acute; a central longitudinal series of wax-bearing lines, a transverse ridge above forelegs; lateral curved lines; dorsal tubercles 24 μ apart, well ahead of rear margin; dorsal setae 4 μ long, projecting up. Legs with femoral seta absent. Forelegs 35 μ long, tibia 7 μ long, tarsus 7.5 μ long; claw 8 μ long, curved, tapering; featherclaw 8-rayed. Hindlegs 35 μ long, tibia 6.5 μ long, tarsus 8 μ long, claw 9 μ long. Coxae strongly lined, the anterior coxae hardly

touching; setae I near apex of forecoxae. Abdomen with three dorsal wax-bearing ridges, flanked on each side by longitudinal troughs, the central ridge ending before the lateral ridges; sternites bearing minute micro-tubercles; sternites and tergites about equal in number and 65-70 each. Lateral seta 30 μ long, on about sternite 10; first ventral 50 μ long, on about sternite 22; second ventral 46 μ long, on about sternite 42; third ventral 25 μ long, on about sternite 6 from rear; accessory seta present. Female genitalia 17.5 μ wide, 14.5 μ long, coverflap with 16-18 longitudinal furrows, in two ranks, seta 20.5 μ long.

Male not studied.

Type locality: Wyandotte, Oroville district, California. **Collected**: November 6, 1942, by the writer. **Host**: *Andropogon* sp., a marsh grass. **Relation to host**: The mites are vagrants on the leaves. **Type slide**: so designated, with the above data. **Paratype slides**: Three in number as above. This mite is distinguished by the long body setae, the lack of femoral setae, the orange-yellow body color, and the yellow rows of tufted wax.

Abacarus Keifer, new genus

Body more or less elongate. Rostrum moderate in size. Cephalothoracic shield sub-triangular, with anterior acuminate lobe over rostrum; dorsal tubercles on rear margin, directing setae caudad. Legs with all usual setae, featherclaw simple. Abdominal tergites nearly as numerous as the microtuberculate sternites, the micro-tubercles suppressed or absent dorsally; tergites formed into three dorsal longitudinal wax-bearing ridges, the central ridge shorter than the lateral ridges and ending in the dorsal trough; all abdominal setae present. Female genitalia a moderate distance behind coxae, the coverflap with one row of longitudinal furrows, the apodeme of normal length.

Genotype: *Calepitrimerus acalyptus* K.
Bul. Cal. Dept. Agr. Vol. 28, p. 490, 1939

Abacarus differs from *Calepitrimerus* by having the dorsal setiferous shield tubercles on the rear margin and so inclined as to direct the setae caudad. These tubercles in *Calepitrimerus* are ahead of the rear shield margin. *Abacarus* not only receives *acalyptus* but also *Callyntrotus hystrix* Nal. This latter species is unharmonious in *Callyntrotus*, as that genus has lines of wax-bearing tubercles, whereas the *Calepitrimerus* complex has wax-bearing bands, as possessed by *hystrix*. The genus name is *Ab* plus *Acarus*.

Abacarus hystrix (Nal.)

Plate 192

Nalepa—Denks, Akad. Wiss. math-natur. Wien. Vol. 77, p. 141, 1904
Nalepa—Marcellia Vol. 25, p. 72, 1929
Pepper—Jr. Ec. Ent. Vol. 35, p. 201, 1942

Female 180-200 μ long, 35-40 μ wide, 45 μ thick, whitish; in life with a central longitudinal stripe of wax, enclosed by a lateral band on each side. Rostrum 30 μ long, antapical seta 8.5 μ long. Shield 50 μ long, 35 μ wide; anterior lobe narrowed above, a spine below; shield with a central ridge, laterally granulate; dorsal tubercles 23.5 μ apart, on rear margin; dorsal setae 20 μ long, projecting caudad. Forelegs 36 μ long, tibia 8.5 μ long, tarsus 8 μ long; claw 9 μ long, curved, tapering; featherclaw 8 rayed. Hindlegs 35 μ long, tibia 7 μ long, tarsus 7 μ long, claw 7.5 μ long. Coxae with strong sternal line. Abdomen with sternites microtuberculate, the microtubercles suppressed or absent on tergites; the central longitudinal wax-bearing ridge ending in the dorsal trough on about the 46th tergite; supralateral wax-bearing ridges extending farther caudad; tergites about as numerous as sternites; sternites 60-65. Lateral seta 35 μ long, on about sternite 6; first ventral 36 μ long, on about sternite 21; second ventral 23 μ long, on about sternite 38; third ventral 27 μ long, on about 4 from rear; accessory seta present. Female genitalia deep basin-shaped externally, 21 μ wide, 16 μ long, coverflap with about 12 furrows, set 40 μ long.

Male 170-190 μ long, 40 μ wide, 35-40 μ thick.

Locality: Sacramento, California. **Collected**: during September and October 1943 by the writer. **Host**: *Elymus triticoides* Buckl., wild rye. **Relation to host**: The mites live in the upper surface furrows of the leaves. This mite has a wide distribution on perennial grasses throughout the northern hemisphere. It is of economic importance in

New Jersey. A common name for the species might be "cereal rust mite". For references previous to this article look under *Callyntrotus* and *Epitrimerus*.

Acamina Keifer, new genus

Body spindleform, somewhat flattened. Rostrum large, the chelicerae evenly curved. Shield sub-triangular, the anterior lobe over rostrum very broad and blunt; dorsal tubercles ahead of rear margin, turned so as to direct the setae ahead and centrad. Legs lacking femoral setae, featherclaw simple. Abdominal tergites nearly as numerous as the microtuberculate sternites; dorsum with three longitudinal wax-bearing ridges, the central ridge ending in the central shallow trough and not as long as the lateral ridges; ventral setae I and II absent. Female genitalia the normal distance behind coxae, coverflap with longitudinal furrows in two ranks; apodeme of normal length.

Genotype: *Calcpitrimerus nolinae* K.
Bul. Cal. Dept. Agr. Vol. 28, p. 151, 1939

The broad anterior shield lobe, the lack of femoral setae and abdominal setae I and II, separate *nolinae* from species properly referred to *Calepitrimerus*. The genus name is a contraction of *Acarus* plus *minus*.

When using the following key, care must be taken not to attempt to properly assign deutogynes. This key is only good for the primary forms. Deutogynes develop on deciduous shrubs and trees, but may be found wandering on other types of plants. They are usually distinguished by the suppression or lack of microtubercles, and in this key will run to the *Phyllocoptes-Vasates* complex. Some are properly assigned to that complex, but many actually belong to the Epitrimeri.

KEY TO GENERA OF THE PHYLLOCOPTINI

Abdomen circular in cross-section or nearly so, lacking long longitudinal furrows or ridges ..... 1.
Abdomen flattened, furrowed, ridged, or with lateral projections ..... 4.
1. Caudal abdominal section, especially the tergites, distinct from anterior section ..... ANTHOCOPTES Nal.
1. Abdominal tergites gradually narrowing to rear ..... 2.
2. Tergites with numerous small lobes, (dorsal setae projecting caudad; female apodeme shortened) ..... GAMMAPHYTOPTUS K.
2. Tergites evenly arched ..... 3.
3. No dorsal tubercles or setae; female genitalia appressed to coxae, the apodeme shortened ..... COPTOPHYLLA K.
3. Dorsal tubercles on rear shield margin, directing setae caudad; female genitalia in normal position with apodeme of usual length ..... VASATES Sh.
3. Dorsal tubercles ahead of rear shield margin, directing setae up or ahead; female genital apodeme of normal length in ventral view ..... PHYLLOCOPTES Nal.
4. Either a broad central longitudinal abdominal trough or a broad central ridge ..... 5.
4. Middorsal furrows or ridges narrow or acuminate, or dorsum flat, or flattened species with dorsum slightly transversely arched ..... 7.
5. A broad central longitudinal dorsal abdominal ridge ..... THAMNACUS K.
5. A broad dorsal trough ..... 6.
6. Dorsal tubercles well ahead of rear shield margin, setae directed up and centrad ..... PHYLLOCOPTRUTA K.
6. Dorsal tubercles on rear shield margin, directing setae caudad ..... TETRA K.
7. Caudal section of abdomen projecting abruptly down on dorsal side; an accessory flap over rostrum (CALIPHYTOPTI) ..... 8.
7. Caudal section of abdomen more or less evenly downcurved, no accessory flap over rostrum (EPITRIMERI) ..... 9.
8. Abdominal dorsum flat, dorsal tubercles near rear shield margin but directing setae ahead ..... CAROLOPTES K.
8. Abdominal dorsum forming low arch, with three longitudinal furrows, dorsal tubercles well ahead of rear shield margin, directing setae ahead and centrad ..... ACARELLIPTUS K.
8. Abdominal dorsum with a central ridge, followed by transverse depression; dorsal tubercles ahead of rear margin, directing setae centrad ..... CALIPHYTOPTUS K.

9. Flattened species with abdominal dorsum evenly or nearly evenly arched, a sublateral furrow present ..... PLATYPHYTOPTUS K.
9. Abdominal dorsum ridged or furrowed; or mite with lateral projections or swellings; no sublateral furrow ..... 10.
10. Abdominal tergites smooth, broad, much less numerous than sternites ..... 11.
10. Tergites more nearly equal to sternites in number, often microtuberculate ..... 13.
11. Flattened species with abdomen swollen laterally just behind shield (featherclaws bifurcate) ..... TUMESCOPTES K.
11. Lateral abdominal projections more or less acute, formed by individual tergites; central ridge present or absent ..... OXYPLEURITES Nal.
11. A central abdominal ridge but no lateral projections ..... 12.
12. Featherclaws simple, rear patellar seta present ..... TEGONOTUS Nal.
12. Featherclaws bifurcate, rear patellar seta absent ..... ACAPHYLLA K.
13. Dorsal longitudinal lines of wax-bearing microtubercles with spines ..... CALLYNTROTUS Nal.
13. Either lacking wax-bearing organs or with wax-bearing ridges ..... 14.
14. A narrow central longitudinal abdominal trough ..... CUPACARUS K.
14. Abdomen with a central ridge ..... 15.
15. Central longitudinal dorsal abdominal ridge as long as lateral ridges ..... 16.
15. Central ridge distinctly shorter than lateral ridges ..... 17.
16. Dorsal setae present ..... EPITRIMERUS Nal.
16. Dorsal setae absent ..... CALACARUS K.
17. Featherclaw bifurcate ..... ACARICALUS K.
17. Featherclaw simple ..... 18.
18. Anterior shield lobe broad and blunt; abdominal setae 1 and 2 missing ..... ACAMINA K.
18. Anterior shield lobe acute; all abdominal setae present ..... 19.
19. Dorsal tubercles ahead of rear margin, directing setae centrad or ahead ..... CALEPITRIMERUS, K.
19. Dorsal tubercles on rear margin, directing setae caudad ..... ABACARUS K.

DIPTILOMIOPINI

Rhyncaphytoptus ulmivagrans K

Keifer—Bul. Cal. Dept. Agr. Vol. 28, p. 420, 1939 (*Rhyncaphytoptus ulmivagrans*)
Keifer—Bul. Cal. Dept. Agr. Vol. 28, p. 491, 1939 (*Abacoptes platynus*)

Rearing experiments have now proved *Abacoptes platynus* is in reality the deutogyne of *ulmivagrans*. The lack of sternal microtubercles on "Abacoptes" harmonizes with other Diptilomiopine deutogynes. However, the flat back is remarkable, and not to be expected on the basis of other hibernating forms. The host in this case is *Ulmus* spp. I have seen specimens of an exceedingly similar deutogyne from the leaves of eastern *Fagus*.

Quadracus Keifer, new genus

Body wormlike, curved. Rostrum large, tapering, with characters of tribe. Shield subtriangular, with anterior lobe over rostrum; dorsal tubercles near rear margin but so inclined as to direct setae up and ahead. Legs with all usual setae, featherclaw simple. Abdomen with broad non-tuberculate tergites, and fine microtuberculate sternites; tergites forming a broad central ridge, and a lateral ridge on each side, the central ridge unevenly serrate in lateral view; all abdominal setae present. Female genitalia with longitudinal scoring on coverflap.

Genotype: *Quadracus urticae*, new species.

This genus is distinguished by the tergal ridges. The name is *Quadra*, plus a contraction of *Acarus*.

Quadracus urticae Keifer, new species

Plate 193

Female about 200 μ long, 45-50 μ wide, 45 μ thick, light yellowish amber, spindleform, curved. Rostrum 42 μ long, set at right angles to body. Shield 32 μ long, 40 μ wide, anterior lobe short, broad, blunt; disc slightly raised and enclosed by curved lines; dorsal tubercles 17.5 μ apart, on rear margin, dorsal setae 25 μ long, projecting forward and out. Forelegs 35 μ long, tibia 6.5 μ long, tarsus 10 μ long; claw 8.5 μ long,

tapering slightly curved, knobbed; featherclaw 5 rayed, palmate. Hindlegs 32 μ long, tibia 6 μ long, tarsus 8.5 μ long, claw 10.5 μ long. Anterior coxae broadly contiguous behind a submental ridge, setae I much further apart than setae II. Abdomen with broad tergites, forming uneven serrations in lateral view; lateral ridge composed of 2-3 times the number of tergites forming the dorsal ridge; sternites microtuberculate; dorsal tergites about 25 in number; lateral tergites about 45; sternites about 80. Lateral seta 11.5 μ long, on about sternite 7; first ventral 10 μ long, on about sternite 24; second ventral 14 μ long, on about sternite 35; third ventral 23 μ long, on about sternite 7 from rear; accessory seta absent. Female genitalia 24 μ wide, 22 μ long, coverflap about 8 furrows, seta 12.5 μ long.

Male about 180 μ long, 45 μ thick, 45 μ wide.

Type locality: Sacramento, California. **Collected**: August 8, 22, and September 2, 1943, by the writer. **Host**: *Urtica gracilis holosericea* Jepson, nettle, Urticaceae. **Relation to host**: The mites occur in the thick hair on the underside of the leaves. No damage was noted. **Type slide**: so designated, bearing the above data and collected September 2. **Paratype slides**: six in number as above.

KEY TO DIPTILOMIOPINE GENERA

Tergites more numerous than sternites ..... PHYLLOCOPYCHES Nal.
Abdomen Eriophyiform or tergites less numerous than sternites 1

1. Sternites lacking microtubercles, dorsum arched or flattened, on deciduous trunks or trees ..... Deutogynes
1. Sternites microtuberculate ..... 2.
2. Featherclaws divided; femoral setae absent; a sternal ridge between forecoxae ..... DIPTILOMIOPUS Nal.
2. Featherclaws simple; femoral setae present; forecoxae connate ..... 3.
3. Tergites fairly evenly arched, at most rather faint subdorsal depressions ..... RHYNCAPHYTOPTUS K.
3. Tergites forming a rough central ridge, flanked by a lateral ridge on each side ..... QUADRACUS K.

DESIGNATIONS ON PLATES

API—Internal female genitalia, including apodeme and glands
D—Dorsal view of mite
DA—Dorsal view of anterior section
ES—Detail of side skin
F—Featherclaw
GFI—Female genitalia and coxae from below
L—Left legs
S—Side view of mite
SA—Side view of anterior part of mite

PLATE 181. *Phytoptus cupressi*, n. sp.

PLATE 180. *Phytoptus pini*, Nal.

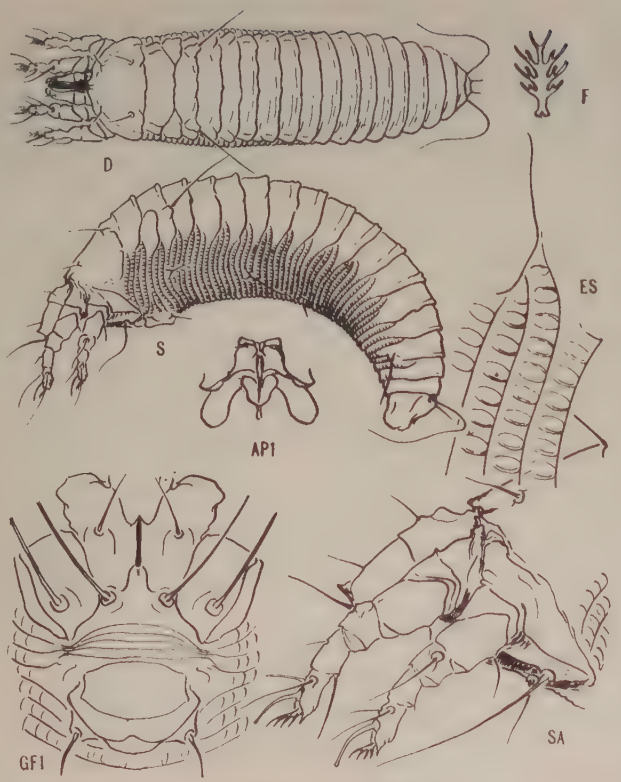


PLATE 182. *Austracus havrylenkouis*, n. sp.

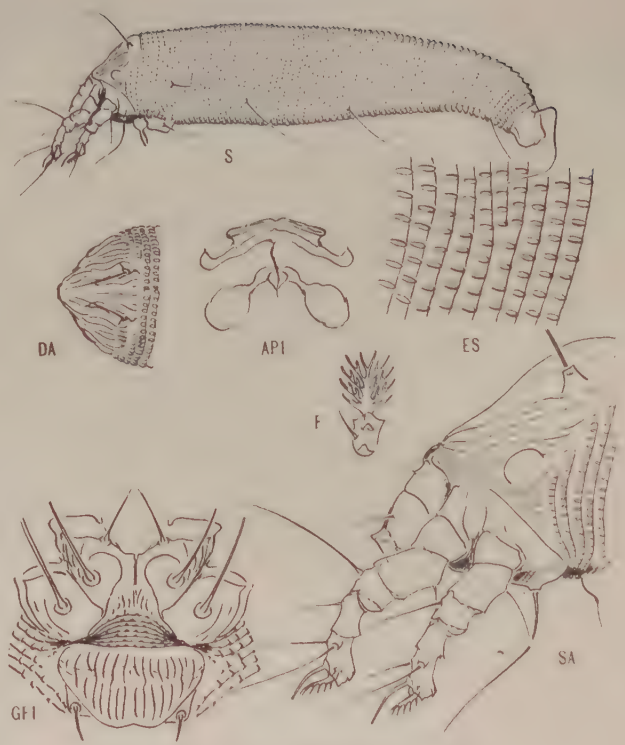


PLATE 183. *Eriophyes vitis*, Pgst.

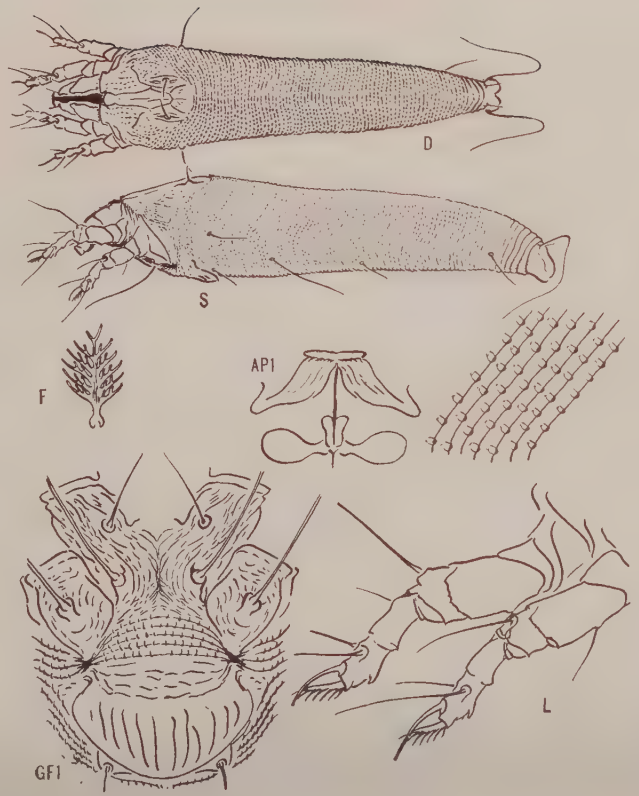


PLATE 184. *Eriophyes caricis*, n. sp.

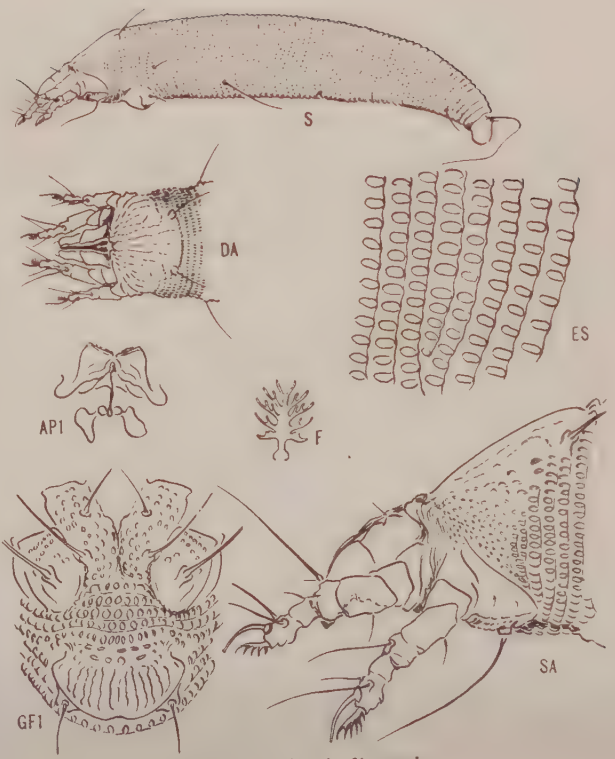


PLATE 185. *Aceria diospyri*, n. sp.

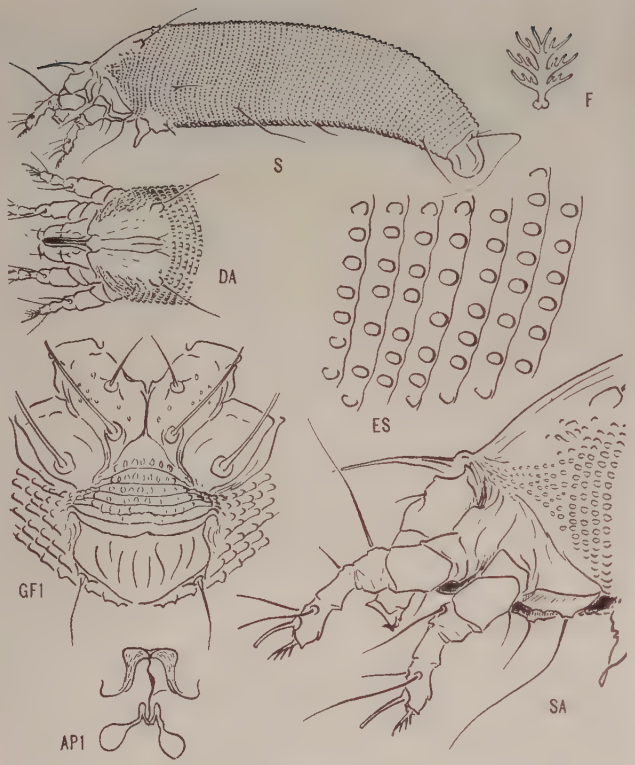


PLATE 186. *Aceria escalloniae*, n. sp.

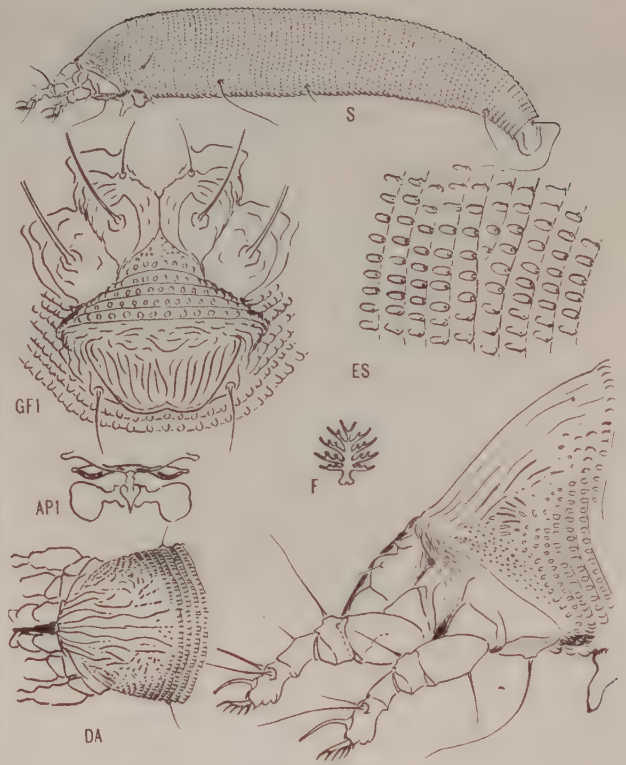


PLATE 187. *Cecidophyes vermiformis* (Nal.)

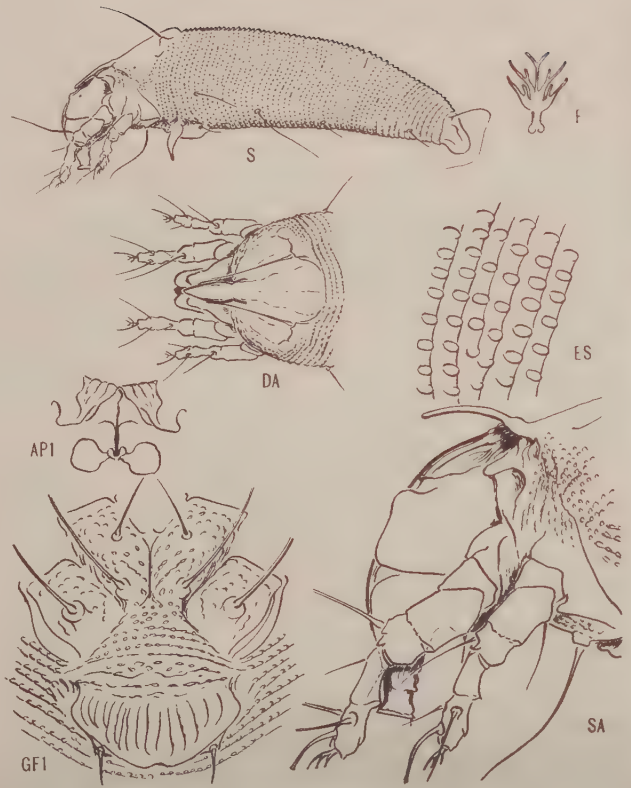


PLATE 188. *Phyllocoptes calisalicis*, n. sp.

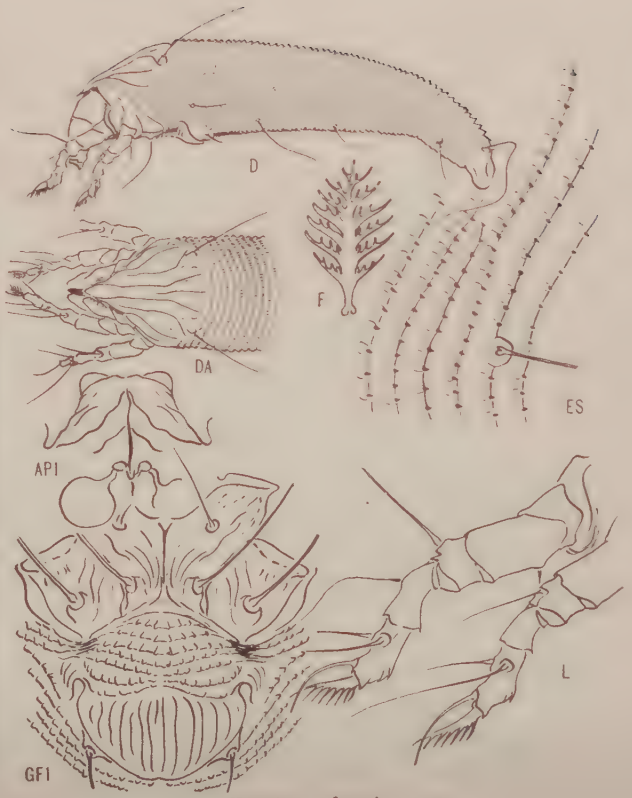


PLATE 189. *Vasates mckenzie*, n. sp.

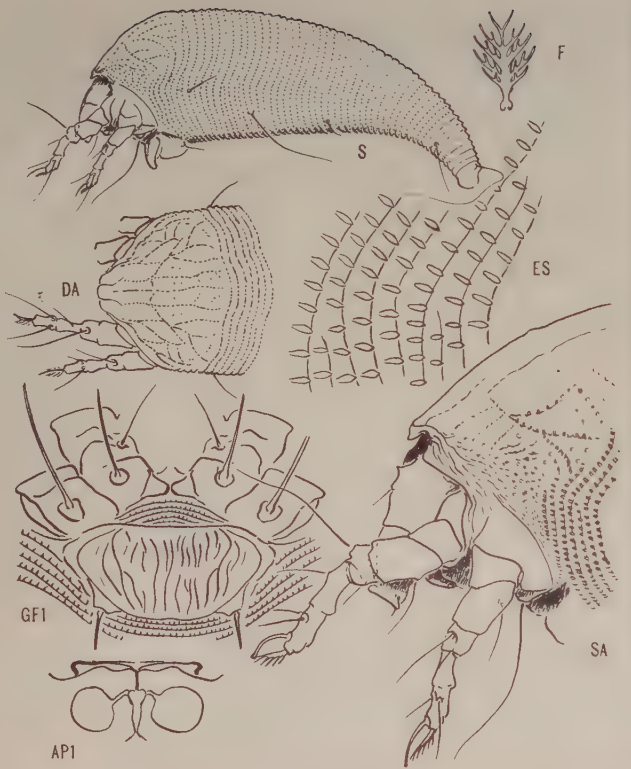


PLATE 190. *Coptophylla caliquerci*, n. sp.

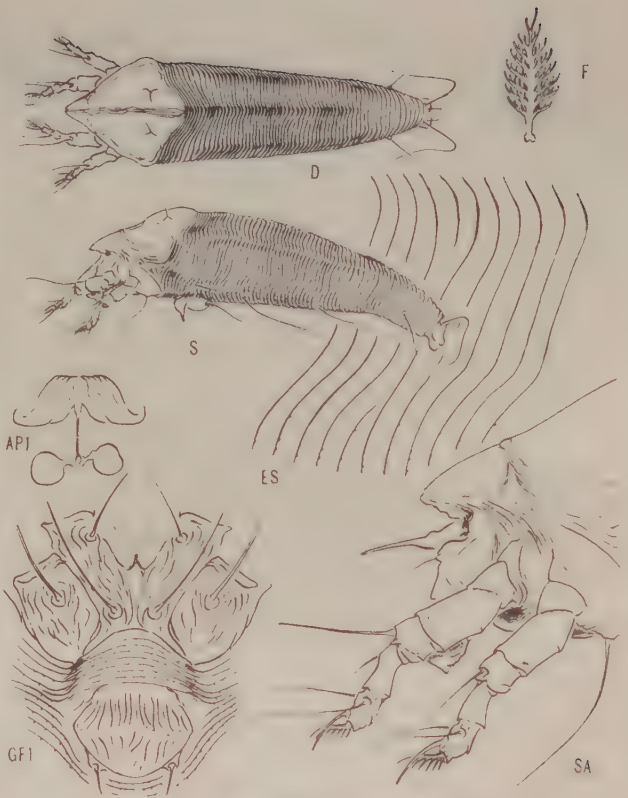


PLATE 191. *Calepitrimerus andropogonis*, n. sp.

PLATE 192. *Abacarus hystrix* (Nal.)

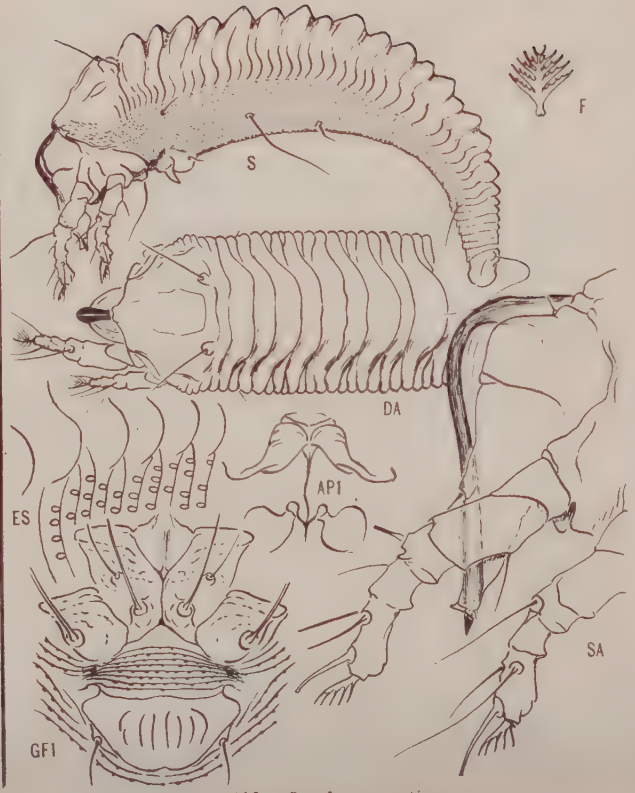


PLATE 193. *Quadracus urticae*, n. sp.

ALFALFA INSECTS IN CALIFORNIA

By Ray F. Smith and A. E. Michelbacher
University of California, Berkeley

Alfalfa is one of the most valuable hay and forage crops produced on irrigated lands, and in California a large portion of the agriculture is built around this crop. When it is properly cared for, a heavy tonnage of hay can be expected. Because of its hardiness and vigorous growth alfalfa is likely to be neglected and frequently does not receive the same care and attention given other crops such as beans, potatoes, sugar beets, and cotton. It is taken for granted that alfalfa will do well and surprise is sometimes expressed when the crop fails to produce as expected, although some other crop would have met with complete failure if accorded the same treatment.

From the entomological point of view, alfalfa has not received the attention to which it is entitled and as a result the insects associ-

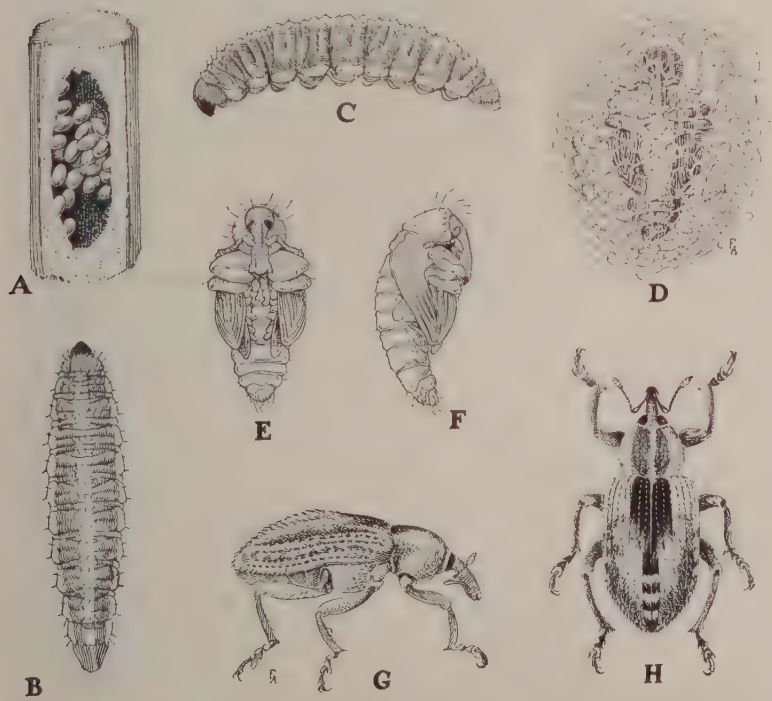


Fig. 1. Life cycle of alfalfa weevil, *Hypera postica* Gyll.: *A*, alfalfa stem cut open showing a cluster of eggs; *B*, dorsal view of last-instar larva; *C*, lateral view of last-instar larva; *D*, pupa within lacelike cocoon; *E*, pupa removed from cocoon, ventral view; *F*, lateral view of pupa; *G*, lateral view of adult; *H*, dorsal view of adult (x6). After Michelbacher (1940a)

ated with it are not properly understood. The importance of insects in alfalfa hay production can not be overemphasized. There are insects which are able to defoliate alfalfa completely despite its rapid and vigorous growth. Throughout the entire growing season there are insects that may seriously attack alfalfa. There are aphids and alfalfa weevils early in the season, and later numerous caterpillars, grasshoppers and true bugs, all of which are considered in the paper.

Plant-feeding insects are attracted to alfalfa fields because of the ample, nutritious food supply and the protection which the growing crop offers. Their parasites and predators are associated with these insects so that within a given field there is a constant conflict between insects which feed upon the plants and those which attack the plant-feeding insects. Whether the plant feeders or their enemies will hold the upper hand is dependent largely upon cultural conditions, location of the field, climate, or even variations in local weather conditions. It is difficult to determine the part played by any of these factors and frequently considerable investigation is necessary before the facts are revealed. Yet this type of information is essential for successful control measures.

Under ordinary conditions large sums of money can not be spent on the control of insects attacking alfalfa. Although it is a very valuable crop, the harvest of alfalfa extends throughout the entire growing season and any particular cutting represents only a relatively small part of the whole. Furthermore, the insecticides which can be used against alfalfa insects are restricted. The use of arsenicals and fluorines is very limited because of the hazard involved in their application to a hay or forage crop. Yet in the case of the alfalfa weevil, *Hypera postica* Gyll. (Fig. 1), a control method which involves the application of from two to three pounds of calcium arsenate to the acre has been developed in the Great Basin Region with satisfactory results. (Snow 1925, Reeves 1927, Newton 1933.) This material can be used with safety because it is so highly toxic to the alfalfa weevil larvae that the dosage necessary for control is very small and there is little danger of a serious residue occurring on the hay. When the application has been timed properly, there is about a 10-day period between application and cutting, and during this interval much of the poison deposited on the foliage is dislodged. Although a suitable chemical control has been developed, farmers have learned to cope with the problem also through cultural means such as timely cutting. Most infestations in California could be taken care of in this manner. The weevil is not a major pest here and frequently when a destructive population develops, the alfalfa is ready to cut at that time or before damage has reached a point where dusting could be justified.

Inorganic chemicals can be used only to a very limited extent and for any general treatment of alfalfa insects, insecticides which are not poisonous to livestock such as those from plant sources must be relied upon. Most of these insecticides are contact poisons and furthermore decompose rather rapidly after being applied. Much of their killing power is based upon contact action, and because these do not remain effective for any great length of time, their use against alfalfa insects has not proved very promising. Many of the insect pests of alfalfa are also very difficult to kill with contact insecticides and this, together with the problems involved in application and relatively high cost,

argue against their use. It is possible that under certain conditions they can be used effectively but before they can be recommended certain facts must be known. The insecticide must be effective against the insect for which it is intended and the conditions for effective application must be known. The seasonal population trend of the pest should also be determined, for without this information timing of applications would be difficult. A knowledge of the interrelationships of the pest and its parasites or predators is also helpful in planning control.

Because of the many obstacles involved in chemical control, a great deal of effort should be directed toward finding cultural means which will lessen insect damage. Such measures are dependent, at least in part, on a knowledge of the pest and this phase of the problem needs serious study. Alfalfa is grown over such a wide range of conditions that an insect problem in one area may not be the same in another, thus it is dangerous to conclude that what may happen in one place will hold true wherever alfalfa is grown. It is necessary to investigate the insect problems of each region.

Our observations have been largely confined to the alfalfa-producing section of lowland middle California. In this region marked differences in insect behavior have been noted. For instance, in the more moderate climate of the coastal region, damage by the alfalfa butterfly has not been

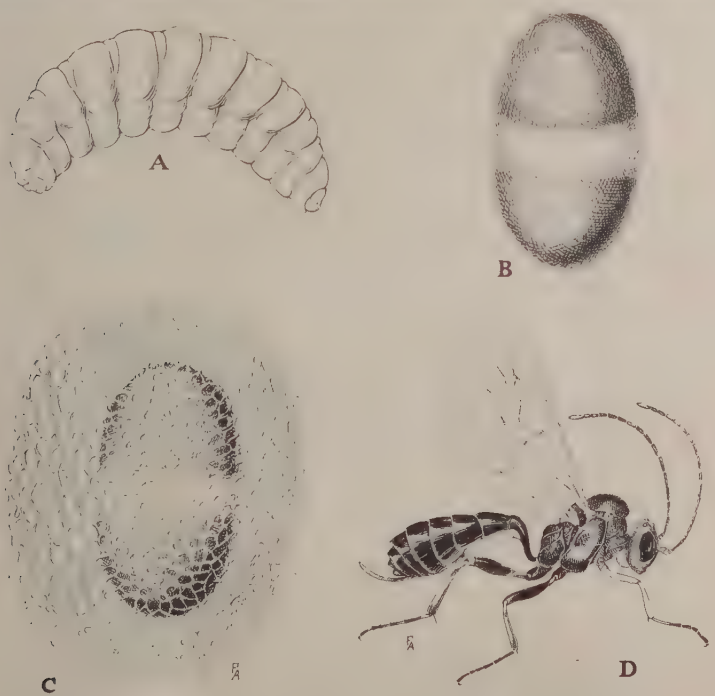


FIG. 2. Life cycle of *Bathyplectes curculionis: A*, mature larva at time of leaving body of host; *B*, cocoon removed from within host cocoon; *C*, cocoon in normal position within cocoon of host; *D*, adult female parasite (x12). After Michelbacher (1940a)

observed whereas in the hotter interior valleys the pest defoliates alfalfa fields on occasions. Marked differences have also been observed in the case of the alfalfa weevil. (Michelbacher and Leighly 1940.) Conditions are relatively more favorable for parasitism by *Bathyplectes curculionis* (Fig. 2) in the more moderate coastal climate than in the warmer interior valleys, and as a consequence the weevil has not been destructive in the former area during recent years. (Michelbacher 1940a, 1940b.) That seasonal population trends are also markedly influenced by climate is well illustrated by contrasting weevil behavior in lowland middle California with its behavior in the Great Basin area. The seasonal activity here is of much longer duration and there are two distinct generations as compared with one in the Great Basin region. The range of climate over which alfalfa can be grown covers the entire range over which the alfalfa weevil is able to exist. Damage is limited on the one extreme by cold and on the other, by heat.

Alfalfa fields serve as excellent winter quarters for many insects. During the dormant season many can be found and if there is very much growth of the alfalfa, some may be present in fair abundance. The following are among the more common insects to be found: in winter, alfalfa weevil, clover leaf weevil, *Diabrotica* beetles, *Lygus* bugs, thrips, aphids, parasites and predators. As the season advances other insects find their way into the fields; there may be large migrations into alfalfa fields and also movements away from them. Bean thrips have been observed to move in large numbers to alfalfa when surrounding bean

FIG. 3. Adult *Apanteles flaviconchae* a very important parasite of the alfalfa butterfly (x17). After Michelbacher and Smith (1943)

fields have been cut. Grasshoppers, lepidopterous insects, and *Diabrotica* beetles have been noted moving into alfalfa fields, while these same insects and others have been observed to migrate from alfalfa. The largest

movement away from alfalfa fields occurs at the time of cutting. *Lygus* bugs may migrate to other cultivated crops in such numbers as to cause serious losses. Grasshoppers have been known to move to surrounding areas, and army-worms have defoliated rows of adjoining crops. Thus alfalfa fields serve as a reservoir of infestation for other crops.

Insects may be very important in the transmission of virus diseases to alfalfa. The work of Weimer (1937) indicated that insects transmitted the virus of alfalfa dwarf. This was proved by Houston et al (1942) who showed that the leafhopper, *Draeculacephala minerva* Ball, was a vector.

The conflict that rages in alfalfa fields between predators, parasites and their hosts reaches large proportions. It has already been pointed out that in the cooler regions of California the larval parasite (*Bathyplectes curculionis*) of the alfalfa weevil is successfully holding that pest in check. It has also been observed that natural enemies of the pea aphid check damage by this pest in the late spring. The part played by natural enemies in reducing the damage done by the alfalfa butterfly is also very important. This is probably the most serious pest of alfalfa in our warm interior valleys and damage would be much greater if it were not for parasitism. This insect is subject to the attack of many insect parasites, and a wilt disease is also important in checking large populations. The balance that exists between this insect and its parasites offers a very interesting study. Parasitism by the larval parasite, *Apanteles flaviconchae*,

FIG. 4. Some immature stages in the life cycle of *Apanteles flaviconchae*. Left, parasitized alfalfa butterfly larva; to right of the alfalfa butterfly larva in upper row a fullgrown larva and two cocoons of *Apanteles flaviconchae;* In lower row three cocoons of *Apanteles flaviconchae* from which the adults have emerged (x5). After Michelbacher and Smith (1943)

Riley (Figs. 3 and 4) alone is so complete that under some conditions it has protected alfalfa from serious damage. Many cases have been observed in which more than 90 per cent of the butterfly larvae were parasitized.

Cultural methods can be utilized to check insect damage to alfalfa. Timely cutting, winter cultivation, and proper irrigation are all useful

measures but are employed most advantageously when population trends to be controlled are known.

Through breeding and selection it should be possible to develop strains of alfalfa that are resistant to attacks by insects. This means of control has shown promise in combating such alfalfa insects as the pea aphid and leafhoppers. (Packard 1941.)

The most important insect pest of alfalfa in California is the alfalfa butterfly, *Colias eurytheme* Bdv. (Fig. 5), seen so abundantly in and about alfalfa fields in the warmer regions of the State. This insect annually destroys thousands of tons of alfalfa. The adult butterflies lay

FIG. 5. Adult alfalfa butterfly; upper row from left to right dorsal view of female and male; lower row ventral view of same. (natural size) After Michelbacher and Smith (1943)

white cigar-shaped eggs scattered over the leaves in the spring and from these eggs tiny larvae hatch and begin to eat the leaves. At first only the epidermis is eaten, but as the larvae increase in size, their demand for food increases and by the time they are half grown they have voracious appetites. The larva (Fig. 6) casts its skin four times before reaching maturity, and when full grown is about 1¼ inches in length. It is usually a velvet green with a white line which contains red markings along either side. Down the back there may be two fine white lines. Upon reaching maturity the larva transforms into a light green pupa which is attached to the stubble on the stems of the alfalfa. After a few days the adult emerges from the pupa. Most of the butterflies are yellow with black markings; however, the females may occur in a white color phase. The males can be distinguished from the females in that they have on the

upper outer surfaces of the wings a solid black border. The females are usually slightly larger and the black border is broken by yellow spots. There are several generations each summer and under favorable conditions the butterfly can complete its development in 25 days or less. The injury is most severe from July to September when whole fields are sometimes reduced to bare stems. In spite of the serious damage that sometimes occurs, this pest is usually effectively controlled by natural factors, the most important being the hymenopterous parasite, *Apanteles flaviconchae* Riley, and a wilt disease (Michelbacher and Smith, 1943). When the natural factors are not effective, artificial control is warranted. At present this consists of timely cutting to destroy the larvae, use of drags to crush them, and irrigation to bring about conditions favorable for the wilt disease. Recent published investigations (Smith and MacLeod, 1943) have shown that dusting sulfur if applied at the rate of 75 pounds to the acre, is effective in controlling the pest.

FIG. 6. Mature larvae of alfalfa butterfly as seen on alfalfa plant (approximately natural size). After Michelbacher and Smith (1943)

The pea aphid, *Macrosiphum pisi* Kalt. (Fig. 7), sometimes attacks alfalfa in large numbers and is particularly a pest early in the growing season. The infestation may be so heavy that developing shoots are unable to grow, as has been observed in the San Fernando and Antelope valleys. Infestations as serious as this have not been encountered in

central California, although on numerous occasions stunting and deformation of the alfalfa have been observed. The damage has been confined to the first crop and if natural factors do not limit the pest, it may be necessary to resort to early cutting. Among the important natural factors controlling the pest are climate, the ladybird beetle, *Hippodamia convergens*, syrphid flies, hymenopterous parasites, and a fungus disease. The importance of these factors has been noted also by other investigators. The fungus disease is very likely to be of greatest importance early in the season and under favorable conditions it may nearly eradicate the pest. This was particularly noticeable in 1941 when an

FIG. 7. The pea aphid, often a serious pest of alfalfa and peas. From extension circular 87 University of California Exp. Sta.

extremely large aphid population developed in the early winter. In a number of fields there were so many aphids in the insect net that it was difficult to swing after making 50 sweeps. Following this outbreak the weather conditions during February and March apparently were favorable for the disease because nearly all the aphids were killed by the fungus.

Under conditions as observed in central California the aphid is not likely to be destructive to the second crop of alfalfa as by this time the natural enemies such as ladybird beetles and syrphid flies have had an opportunity to build up to a point where they can easily hold the pest in check. Even in the case of a serious infestation the alfalfa usually need not be cut before the normal cutting date and the loss incurred is usually not serious. In many cases early cutting of the first crop may be beneficial, particularly if the field is weedy or the hay is of poor quality. Following the cutting, alfalfa makes a vigorous and rapid growth and the increase in tonnage and quality probably greatly exceeds that which might otherwise have resulted.

On the first crop and in other cases where the pea aphid is not controlled by its enemies, artificial control is needed. However, at the

present time, no satisfactory control has been developed. Use of cultural practices such as winter pasturing, winter cultivation, and timely cutting are helpful (Blanchard, 1934).

Several grasshoppers, including the red-legged locust, *Melanoplus femur-rubrum* (DeG.), the marginate grasshopper, *M. marginatus* Scud. (Fig. 8), and the differential grasshopper, *M. differentialis* Thomas, are frequently serious pests of alfalfa and usually can be controlled

FIG. 8. *Melanoplus marginatus* (Scudd.) After Wilson and Keifer. California State Department of Agr. Bulletin Vol. 30, No. 3.

with poison baits. Baiting trap strips frequently gives added efficiency to the baits.

A large number of lepidopterous larvae other than the alfalfa butterfly attack alfalfa. The yellow-striped armyworm, *Prodenia praefica* Grote (Fig. 8), is sometimes very destructive. This is a very large velvety black larva with two prominent and many fine yellow stripes on the side of the body, and measures from $1\frac{1}{2}$ to 2 inches when mature. This insect is subject to attacks by parasites and a wilt disease is important in reducing large populations. If it were not for the high environmental resistance encountered, this pest would be a constant menace to alfalfa during the hottest portion of the summer. When the population trends are known, timely cutting can be utilized to reduce damage. The beet armyworm, *Laphygma exigua* (Hbn.) (Fig. 10A), and the alfalfa

semi-looper, *Autographa californica* (Speyer) (Fig. 10B), are common in alfalfa fields of central California but they have not been observed to damage the crop seriously.

FIG. 9. The yellow-striped armyworm, *Prodenia praefica* Grote (actual size). (From U. C. Expt. St. Ext. Cir. 61.)

The alfalfa weevil, *Hypera postica* Gyll. (Fig. 1), is a very serious pest of alfalfa in the Great Basin area of the United States, but is not a major pest in California. The adults are small, brown weevils, $\frac{3}{8}$ inch long, with a dark central band on the elytra. The larvae, which do by far the most damage, are bright green, about $\frac{1}{4}$ inch long, with a small black head and a white stripe down the back. The larvae are legless. In the cooler regions this insect is controlled by *Bathyplectes curculionis*

FIG. 10. A, full-grown larvae of the beet armyworm; B, full-grown larvae of the alfalfa looper. From Bulletin 625, University of California Exp. Sta.

(Fig. 2), and in warmer regions is restricted by climate, frequent cuttings, and other cultural practices. Damage has been restricted to very localized areas.

The clover leaf weevil, *Hypera punctata* (Fabr.) (Fig. 11), is very similar in appearance to the alfalfa weevil except that the various stages are larger. The adult is about ¼ inch long. In the small larvae the posterior half of the body is pinkish, and when mature the white stripe down the back is bordered with pink lines. The clover leaf weevil exists over a wide portion of central and northern California where it occurs

FIG. 11. The clover leaf weevil, *Phytonomus punctatus* (Fabr.) (*Hypera punctata*), a common insect in alfalfa fields often confused with the alfalfa weevil. (From *Insects of Western North America,* Macmillan Co. Reproduced by permission of the copyright owners.)

both in cultivated and uncultivated regions. We have not found it injuring alfalfa seriously although it has been reported as a pest in other sections of the United States. (Tower and Fenton 1920, Herrick and Hadley 1922, and Larrimer 1926.) On only two occasions was it found in abundance, once on *Melilotus indica* growing along a roadside, and recently in the same area on a very small patch of young alfalfa. The larva is very susceptible to a fungus disease which occurs throughout the range of this insect and in California; climatic conditions are apparently so favorable for the development of this disease that the insect is held almost completely in check.

The clover root curculio, *Sitona hispidulus* (Fabr.), is found commonly in alfalfa fields, but does not appear to be a serious pest. However, damage is difficult to detect because the larvae feed upon the roots. Wildermuth (1910) and Webster (1915) have reported damage in eastern United States, and Dean and Smith (1935) described damage in Kansas.

Lygus bugs, *Lygus hesperus* and *Lygus elisus,* are very common in alfalfa fields and often are very abundant. Injury to hay crops is

rarely if ever serious, while seed crops are often seriously attacked. These pale green and brown bugs suck plant juices, causing the blossoms to drop and the developing seeds to shrivel. When large populations

FIG. 12. The cotton dauber, *Lygus hesperus* Knight: *A*, adult; *B*, fifth instar; *C*, fourth instar; *D*, third instar. (Allx5.) From Bulletin 660, University of California Exp. Sta.

threaten a seed crop, the field should be cut while it will still make good hay.

Diabrotica 11-punctata Mann. (Fig. 13) is very common in alfalfa fields and occasionally causes some damage to newly planted fields.

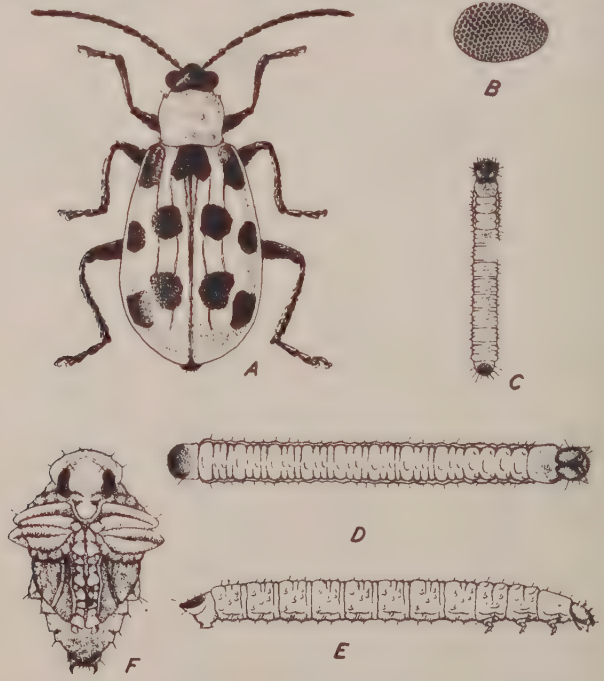


FIG. 13. Life cycle of the Western spotted cucumber beetle, *Diabrotica 11-punctata* Man.: *A*, adult; *B*, egg; *C*, newly hatched larva; *D*, dorsal view of full grown larva; *E*, lateral view of full grown larva; and *F*, ventral view of pupa. From Bulletin 681, University of California Exp. Sta.

Both the adults and larvae are pests. The adult beetle is green with black appendages and head and with 12 black spots on the wing covers. No satisfactory control is available.

Many other insects attack alfalfa in California. Some of these are of little concern, but others are quite abundant and their economic importance has not yet been established. In this latter category are thrips, treehoppers, and leafhoppers.

Conclusions: From a study of the insects attacking alfalfa it is apparent that the control of many of them could be improved if more were known concerning their habits. In part they are controlled by climate, parasitism, disease and cultural methods. It is important that the part these factors play in limiting the insect and also the seasonal trends of the pest be determined. With this knowledge available it should be possible to develop control measures that would be useful in further limiting damage. Although chemical controls have been developed for certain insects, such measures are limited not only because of their cost but because the insecticides which can be used are rather restricted.

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MISCELLANEOUS DIASPID SCALE STUDIES

(HOMOPTERA; COCCOIDEA; DIASPIDIDAE)

By Howard L. McKenzie
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This article includes descriptions of three new Diaspid scale insects, of which two belong to the Tribe Aspidiotini and one to the Tribe Diaspidini. It also includes a figure of *Aonidiella eugeniae* (Hempel) and discusses certain morphological details of this species. One of the described scales has become established on Arizona ash in California, while the remaining two have been sent here from foreign countries. On the basis of injured plant material on hand, one of the latter of these appears to be a serious pest of quinine in Bolivia, South America.

Mr. H. H. Keifer of this Department has kindly reviewed the present article and made several constructive comments about it. To him I am extremely grateful.

The Genus **Hemiberlesia**, Cockerell

Specimens representing the new species of *Hemiberlesia* described below were sent to this Department for identification by Mr. F. R. Platt, Deputy Agricultural Commissioner of Riverside County, Riverside, California. An additional collection of this species was made at the request of the present author and to Mr. Platt acknowledgments are here made.

Professor Ferris of Stanford University has examined this form and is in full accord with the author that it represents a new species.

Hemiberlesia fraxini McKenzie, new species

Figure 1

HOSTS AND DISTRIBUTION. Type and paratypes collected from *Fraxinus velutina*, Arizona ash, on W. S. Rosecrans' property at Indio (near La Quinta), Riverside County, California, on December 17, 1943, by Mr. F. R. Platt, Deputy County Agricultural Commissioner of Riverside County, California.

HABIT. Occurring on the leaves of *Fraxinus velutina*, Arizona ash, the species causing noticeable injury by removing the chlorophyll from the leaf tissue.

RECOGNITION CHARACTERS. Scale of the female circular averaging 1¼ mm. in diameter, width ⅞ mm.; prosomatic region membranous at maturity; three pairs of pygidial lobes present, the median pair largest, once-notched on either side, the

All but one of the species of Diaspid scales described or otherwise treated in this paper are from among numerous lots of scale insects which have been received for identification in the insect taxonomy office. This information is published not only to further clarify identification problems in this economically important group of insects, but also to complete the identification work of the Diaspids for the period during which these species were received.—Author's note.

second pair smaller and similarly notched and the third pair represented as a sclerotized point with the outer margin commonly once-notched; *perivulvar pores present in four groups* (occasionally a single anterior median pore is present); *anterior groups ranging from seven to ten pores each*, posterior group from three to seven each; pygidial plates fimbriate, shorter than the lobes, two situated between the median lobes, two between the median and second lobes, three between the second and third lobes, and a few, usually three to five, short, pointed, single plates beyond the third lobe; *dorsal macroducts present and situated as indicated in Figure 1;* ventral microducts present in a series extending from the pygidium along the margin to the first abdominal segment, a few also located on the prosoma; intersegmental paraphyses between the sixth and seventh and seventh and eighth segments developed as in typical *Hemiberlesia;* anal opening with a diameter slightly less than the length of the median lobes and removed by about three times this diameter from the bases of the lobes; small spur present near margin on prosoma opposite anterior spiracles.

NOTES. This species is closely related to *Hemiberlesia colorata* (Cockerell) but differs in the total absence of supernumerary perivulvar pores and in the arrangement of dorsal macroducts on the pygidium.

The type specimen of this species will be deposited in the United States National Museum collection at Washington, D. C. and paratypes in the State Department of Agriculture collection at Sacramento, California.

The Genus **Melanaspis**, Cockerell

Specimens of the *Melanaspis* species described below have been received from Mr. V. E. Williams, Entomologist, Los Angeles County, California. Mr. W. N. Ross, Supervising Maritime Quarantine Officer, San Francisco, California, has kindly made available a portion of the previously fumigated host material infested with this scale insect. Acknowledgments are here due both of these gentlemen.

Professor G. F. Ferris, Stanford University, California, has carefully examined specimens of this species and made valuable comments with regard to its relationship to other species of this genus. To him I am indeed grateful.

Melanaspis tenax McKenzie, new species

Figure 2

HOSTS AND DISTRIBUTION. Type and paratypes taken from *Odontoglossum Rossii* in quarantine from Guatemala on May 5, 1943, at San Francisco, California, by R. D. Clemens, Inspector. Additional specimens of this species are at hand taken on *Cattleya* sp. in quarantine from Colombia, South America, on January 7, 1942, destined to a nursery in Burbank, California, by L. E. Meyers. This shipment originally came through the port of San Francisco, Californnia.

HABIT. Occurring on pseudobulbs of *Odontoglossum Rossii* and presumably on the leaves of *Cattleya* sp. Scale of the female circular, averaging 1¼ mm. in diameter, chocolate brown with exuvium subcentral; scale of the male elongate, similar in color but smaller than that of the female, exuvium near one end.

RECOGNITION CHARACTERS. Length mounted 1 mm., width ⅞ mm.; prosomatic region membranous at maturity; pygidium relatively broad, its dorsum presenting a definite pattern of sclerotization; perivulvar pores absent; four pairs of well-developed pygidial lobes present, the median and second pairs narrowest, the third and fourth pairs broader, all notched on outer margin; pygidial plates short, poorly-developed, two between the first and second and second and third lobes and

three between the third and fourth lobes; dorsal macroducts very few and slender; microducts situated ventrally, usually two extending from between the third incision (that is the area between third and fourth lobes), *a group of six or seven extending from beyond the fourth lobes*, and two or three extending from beyond the seta which marks the position of the fifth segment; paraphyses strongly developed, a single large one arising from the base of the median lobes, two between the first and second incisions, *a series of four or five slender ones in the third incision and a series of usually three or four smaller ones arising from the margin beyond the fourth lobes;* ventral side of pygidium *with an area of well-developed serrate squamations on each side of vulva;* anal opening small and removed from the margin by about one-third the length of the pygidium; cephalothoracic area bearing a considerable number of microducts particularly on the ventral surface between the antennae and anterior spiracles; prosoma possessing a dorsal cicatrix near margin on second abdominal segment.

NOTES. This species is very closely related to *Melanaspis coccolobae* Ferris, but differs from it by the presence of a group of ventral microducts extending from beyond the fourth pygidial lobes; four or five slender paraphyses between the third incision (that is the area between the third and fourth lobes); three or four small paraphyses arising from the margin beyond the fourth lobe; the position of the anal opening, this being closer to the pygidial margin than in the case of *coccolobae*.

The type specimen of this species will be deposited in the United States National Museum collection at Washington, D. C., and paratypes in the State Department of Agriculture collection at Sacramento, California.

The Genus **Aonidiella**, Berlese and Leonardi

During 1940 specimens of a described *Aonidiella* from São Paulo, Brazil, were taken in quarantine at Washington, D. C. The specimens were made available for study to the present author by Drs. C. F. W. Muesebeck and Harold Morrison. I wish to thank these individuals for kindly lending me this material for examination.

Aonidiella eugeniae (Hempel)

Figure 3

NOTES. At the time of the issuance of the author's revision of *Aonidiella*,[1] specimens of this species were not available for study or illustration. It was necessary, therefore, to use a facsimile reproduction of the species used in connection with the original description of it. Certain vagaries were evident on the reproduction and it has seemed advisable to refigure this species since specimens of it have subsequently become available. The specimens from which Figure 3 has been prepared were intercepted at Washington, D. C. from São Paulo, Brazil, January 17, 1940, on *Eugeniae cauliflora* (Jaboticaba), Gouldman, collector, (E. Q. 067771). Only prepared specimens on microscope slides have been seen by the author, there being no unmounted material available for study.

Attention is here called to the definite sclerotization of the prosomatic region and to the character of the paraphyses and sclerotization on the pygidium. (See Figure 3).

[1] McKenzie, Howard L.
1938. The genus *Aonidiella* (Homoptera; Coccoidea; Diaspididae) Microentomology. Volume 3, part 1, pp. 1-36. Illustrated.

The Genus **Chrysomphalus**, Ashmead
Chrysomphalus bifasciculatus Ferris

Several requests have recently been made relative to hosts of the so-called bifasciculate scale, *Chrysomphalus bifasciculatus* Ferris.

The State Department of Agriculture has received considerable lots of this scale for determination during the past few years and comments concerning its host range[1] may be here given.

It is interesting to note that the scale is apparently quite omniverous in its feeding habits and occurs on many hosts both in nurseries and out of doors. Infestations of *bifasciculatus* on *Hedera helix* and *Euonymus* sp. (both plants growing out of doors) appeared very severe and demonstrated marked injury to the attacked host.

In addition to *Aspidistra* sp. (in California) and *Euonymus japonicus* (in Japan), previously recorded by the present author in his revision of *Chrysomphalus*,[2] the scale has been taken in California on *Ampelopsis tricuspidata*, *Aralia* sp., *Aucubo japonica*, *Camellia japonica*, *Catha edulis*, *Cinnamomum camphora*, *Citrus* sp., *Cycas revoluta*, *Cyperus alternifolius* (umbrella sedge), *Elaeagnus* sp., *Euonymus japonicus*, *Ficus* spp., *Hakea saligna*, *Hedera helix*, *Ilex aquifolium*, *Laurocerasus officinalis*, *Laurus nobilis*, *Libertia* sp. (Liberty grass), *Ligustrum japonicum* (Japanese privet), *Nerium oleander*, *Olea* sp., *Ophiopogon* sp., *Phoenix canariensis*, *Pittosporum* sp., *Prunus ilicifolia*, *Rhus* sp., and *Strelitzia reginae*.

The Genus **Protodiaspis**, Cockerell

Specimens of a species of this genus were sent to the State Department of Agriculture by Dr. C. F. W. Muesebeck, in charge of the Division of Insect Identification of the Bureau of Entomology and Plant Quarantine at Washington, D. C. Leaf galls containing specimens were originally sent to the Washington office by Professor M. Cardenas, Universidad Antonoma de Cochabamba, Bolivia. It was believed that these galls were caused by the activity of Eriophyid mites. Since Mr. H. H. Keifer of this Department is a specialist on Eriophyid mites, the above-mentioned material was sent to him for examination. Mr. Keifer is wholly responsible for finding the scale insects within the tiny leaf galls.

In view of the fact that the host of this scale insect is quinine, a plant so important during this war period, and that the leaf specimens at hand appear to be so seriously injured as the result of the galls formed by this insect, it has seemed advisable to describe this species of scale insect.

The genus *Protodiaspis,* type *parvula* Cockerell, as arranged in Ferris' Atlas of Scale Insects, leaves the reader with the distinct impression that a knowledge of the taxonomy of additional but as yet undiscovered species will surely indicate ways of regrouping these forms. The present new species, *cinchonae,* seems to be a step in this direction.

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[1] Some of the host species listed below are from records received from the Office of the County Agricultural Commissioner of Los Angeles County, California.

[2] McKenzie, Howard L.
1939. A revision of the genus *Chrysomphalus* and supplementary notes on the genus *Aonidiella* (Homopetera; Coccoidea; Diaspididae) Microentomology. Volume 4, part 2, Illustrated.

All of the kinds heretofore known are on oak in various parts of North and Central America. "*Protodiaspis*" *cinchonae* is geographically and bionomically far removed from these, and may indicate the answer to this problem lies in further collection and study of Central and South American material.

Both Professor G. F. Ferris and Dr. Harold Morrison have examined this scale species and offered suggestions regarding its relationship to other Diaspid scales. Acknowledgments are due both of these gentlemen.

"Protodiaspis" cinchonae McKenzie, new species

Figure 4

HOSTS AND DISTRIBUTION. Type and paratypes on *Cinchona Calisaya* variety *Josephiana* (quinine) from La Pas, Coroico, Bolivia, collected February, 1943, by M. Cardenas (Federal No. 43-8324).

HABIT. Female scale occurring within tiny green leaf galls, strongly resembling those produced by many Eriophyid mites (see Figure 4); scale of male unknown.

RECOGNITION CHARACTERS. Length mounted on slide averages about 1¼ mm., width ⅝ mm.; derm at full maturity membranous; pygidium acute; perivulvar pores lacking; median pygidial lobes widely separated, divergent, second and third lobes irregularly shaped but definitely present (see Figure 4); dorsal macroducts short and small, two-barred, numerous and scattered over pygidium; ventral microducts as shown in Figure 4; anal opening located about one-third way up on pygidium; vulva situated at about center of pygidium; antennae three-spined.

NOTES. This species appears to be somewhat related to *Protodiaspis praetexta* Ferris but differs in that it possesses a more acute pygidium, far greater number of dorsal macroducts, lacks disc pores associated with anterior spiracles, and has a membranous prosoma.

The type specimen of this species will be deposited in the United States National Museum collection at Washington, D. C., and paratypes in the State Department of Agriculture collection at Sacramento, California.

LEGENDS FOR FIGURES

Figures 1-4

A, pygidium of the adult female; B, details of the dorsal aspect of the pygidial margin; C, habit; D, body of adult female. Unlettered details are connected to their points of origin by guide lines and should be readily identifiable.

All figures have been prepared by the author. They are based upon well-stained material, which emphasizes the derm sclerotization.

FIGURE 1. *Hemiberlesia fraxini*, n. sp.

FIGURE 2. *Melanaspis tenax*, n. sp.

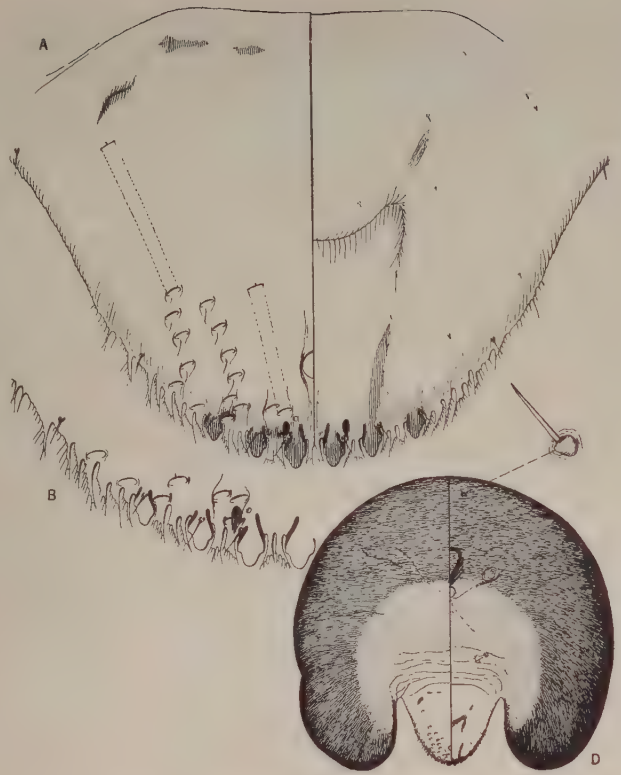

FIGURE 3. *Aonidiella eugeniae* (Hempel).

FIGURE 4. *"Protodiaspis" cinchonae,* n. sp.

A BUD FAILURE DISORDER IN ALMOND TREES

By E. E. Wilson, Associate Plant Pathologist, California Agricultural Experiment Station, and Gilbert L. Stout, Associate Plant Pathologist, California Department of Agriculture *

For a number of years a disorder in almond trees characterized by a failure of buds and shoots and a peculiar type of twig and limb growth has been a cause of concern to almond growers and others interested in almond production in California. The malady has been observed in many localities, particularly in the north central part of the State. From time to time various people have called it to the attention of agricultural specialists. Its cause is not known, but certain orchard and nursery stock source histories suggest that the disorder is being disseminated through budding or grafting or propagation of nursery stock from affected trees.

Investigations to determine the cause and a possible means of control of the malady are being made. In the meantime it has seemed advisable to describe the disorder and to emphasize caution in the selection of trees from which propagative material is to be used. In the exercise of this caution a knowledge of the principal characters of the disorder is of particular importance to those who collect scions and budwood. Not all almond trees are affected with equal severity, and considerable care and diligence are necessary in recognizing the more mildly affected trees. Severely affected trees can be recognized and avoided more easily.

The general appearance and behavior of affected trees has suggested such names as bud failure, bud shattering, crazy top, mule tail, and witch's broom.

The bud failure disorder has been observed principally in the Nonpareil and Peerless varieties, but a similar condition occasionally has been seen in Drake. In plantings of mixed varieties containing both Nonpareil and Peerless it often has been observed that many trees of one variety may be affected while none of the other variety show symptoms. There are some differences in symptoms between varieties. This is true to the extent of leading a student of the disorder to suspect at times that more than one specific malady and cause may be involved.

The chief and outstanding character of the disorder in all varieties is a failure of many of the buds to live and develop into new growth (Fig. 1E). On some twigs all of the buds fail to grow, leaving the twigs bare and devoid of foliage (Fig. 1D, upper left). These twigs retain life for a while but gradually become dry and dead. On other twigs some buds survive. The shoots which develop from the surviving buds appear to be normal during their first season. By the following season, however, many of the buds on these shoots likewise fail. Again the surviving

* Lee M. Hutchins of the United States Department of Agriculture, and H. Earl Thomas of the California Agricultural Experiment Station, started some of the work on the almond bud failure disorder. Among others who have contributed to the studies are L. C. Cochran and Milo N. Wood of the United States Department of Agriculture, Walter L. Stile, Agricultural Commissioner of Butte County, and Henry P. Everett of the Butte County Agricultural Extension Service. Mr. Stile also provided land and care for experimental plot trees. In an annual report, D. G. Milbrath of the California Department of Agriculture in 1939 (Bull. Calif. Dept. Agri. 28(10):572-573) referred to the disorder in Nonpareil and Peerless almonds.

buds produce the next season's new growth, and thus the cycle is repeated from year to year.

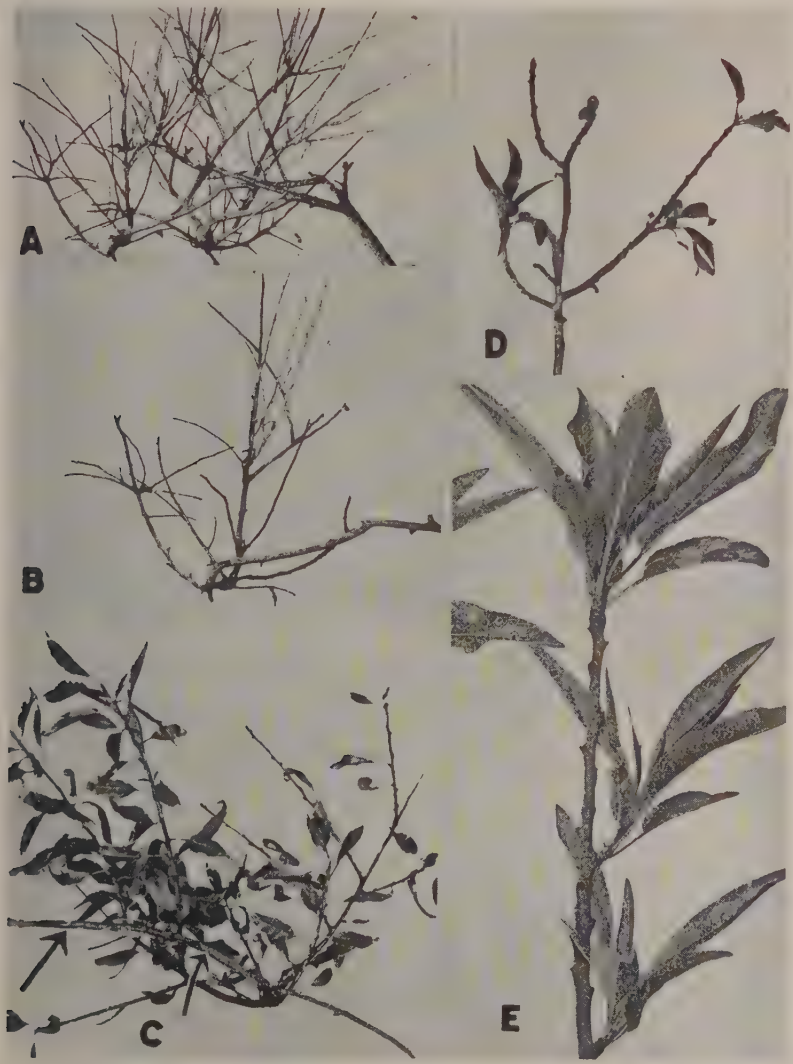

FIG. 1. Bud failure in almond. A and B, dormant branches from affected Peerless variety, showing crooked, bushy growth resulting from successive failure of terminal buds and subsequent development of shoots from lateral buds. C, affected branch of Peerless during growing season showing sparsity of foliage and one secondary branch growing back on the main branch. The main branch is indicated by arrows. D, affected branch of Drake variety on which most of the buds failed. On upper left twig all buds failed. E, all but three buds failed on this affected twig of Drake. Those which grew will develop into shoots rather than spurs.

Limb elongation on the affected trees is more or less normal, but some twigs do not attain a normal diameter and as a result appear slender and willowy. Having been deprived of many of their lateral buds, the limbs have long bare spaces where no leaves, spurs, or branches are present.

Where the terminal bud is among those which die, or where an entire terminal shoot dies, limb elongation is provided by other buds. The shoots formed from these buds sometimes are at marked angles with the twigs from which they arise. Repetition of this procedure results in a crooked limb.

From the foregoing discussion the reason for application of the term, bud failure, to the disorder is obvious. Because many of the buds which die eventually fall away from affected shoots, the term, shatter bud, was suggested. The shoots which grow from the surviving buds frequently are formed at various and peculiar angles to the shoot from which they arise. Sometimes they elongate in a direction reverse to the growth direction of their mother shoot, so that a sharp back turn is made, and the resulting limb appears to bend and grow back on itself (Fig. 1, A, B, and C). The resulting disorderly arrangement of twigs and branches suggests the term, crazy top. Sometimes many shoots grow out close together in a sort of whorl or brushy arrangement suggesting a witch's broom as shown in Fig. 1, A, B, and C. At other times, particularly in the Nonpareil variety, a cluster of shoots occurs at the end of a long bare branch, and the name, mule tail, is then suggested.

In Fig. 2A is shown, in winter aspect, the type of twig and limb growth which occurred on a rather severely affected Nonpareil almond tree. In contrast, in Fig. 2B, is shown the growth on a normal tree of the same age and variety growing next to the affected tree in the orchard. The scarcity of lateral spurs on the affected tree is especially noticeable.

In the spring a delay in the blooming of affected trees has been seen. However, the blossoms on these trees do not exhibit any apparent abnormalities, although by reason of the bud failure condition they are fewer in number than on normal trees. On some twigs fruit buds survive more abundantly than leaf buds, and many nuts set on such twigs. Sometimes the latter, at the same time, largely or entirely are devoid of leaf buds, and therefore of leaves. The total amount of nuts produced on severely affected trees is much less than on normal trees.

Leaves appear to be normal on affected trees, but the total amount of foliage is less because many leaf buds fail. The smaller amount of foliage is particularly noticeable during the early part of the foliage season. However, among those leaf buds which do develop, the tendency is for them to grow into elongated, leafy shoots rather than into spurs, and therefore, by the end of the growing season, a fairly large amount of foliage has developed even on severely affected trees. During the period when the first young leaves are attaining full length, severely affected trees may have a much smaller amount of foliage than on adjoining normal trees of the same age and variety.

Ordinarily, an entire tree is affected and shows the symptoms of the disorder throughout. Occasionaly, however, one or more branches or limbs may be affected while the rest of the tree is normal, or the reverse may be true. When a part of a tree has been found to be affected, definite

evidence of the disorder spreading to other parts has not been observed. On the other hand, affected parts or affected trees thus far are not known to recover.

There is no conclusive evidence that the malady spreads from tree to tree in the orchard. In certain plantings it may appear in some trees

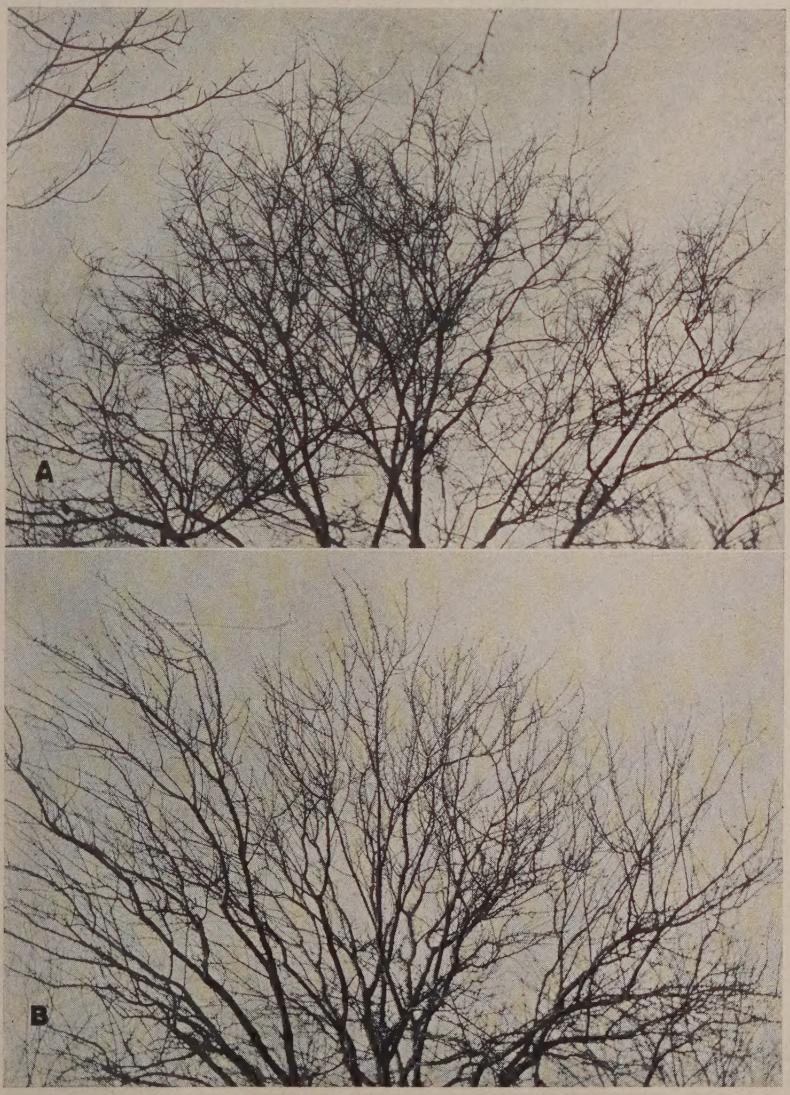

FIG. 2. Bud failure in almond. Limbs of affected and normal trees of Nonpareil variety in winter aspect. A, affected tree, showing deranged, willowy, and brushy type of growth and scarcity of normal lateral spurs and branches. B, normal tree showing abundance of lateral spurs and branches.

after they have been in the orchard for two to three years, and, during subsequent seasons, develop in additional trees. Development of symptoms, however, may be so slow that the first evidence is overlooked. When affected older trees are dehorned, the new growth which arises appears normal for the first two or three years, but it eventually develops symptoms. Whether or not affected trees can be top worked with scions of the same variety from normal trees and a permanently normal new top developed is not yet conclusively proved. Observations on scions from normal trees grafted into affected trees have not been made over a long enough period of time to determine whether or not they will remain normal.

Entire trees are not known to die directly as the result of the disorder.

A possibility that the malady is caused by a virus has been considered, but thus far evidence is inconclusive. Scion and bud inoculation trials to date have not resulted in unmistakable evidence of transmission within three to four years after inoculation. Investigations along this line are being continued.

It also has been suggested that the disorder may have originated through bud variation, but if so it seems to have occurred in more varieties than one.

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